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The Indian Monsoon Rains.*

It is a truth so abundantly illustrated by the famines of recent years as to amount almost to a truism, that in the state of assured peace conferred by the British rule, the well-being and prosperity of the people of India depend, above all things, on the sufficiency and seasonableness of the rainfall.

In a country which derives its wealth almost exclusively from agriculture, this must always be the case; for, however much we may succeed in mitigating the disastrous effects of a season of drought by extending irrigation, and may equalize the incidence of scarcity by improving transport and facilitating trade, we can at best but mitigate the disaster and suffering: we can neither control the cause nor more than partially avert the loss.

But although we can no more control the weather than we can still the earthquake or extinguish the volcano, it may still be possible in some measure to foresee, and foreseeing, to prepare to meet whatever vicissitudes may be in store for us. Capricious and lawless as seem the changes of our weather, and the irregularities of our seasons, no physicist doubts that they are as rigorously conformable to law as are the rising and setting of the sun, or the ebb and flow of the tides; and such being the case, a knowledge of the chain of processes by which they are brought about is, as far as we can see, only a question of time and patient inquiry.

In India, the prosecution of this inquiry is attended with fewer difficulties than fall to the lot of most of those who engage in similar inquiries in Europe. In the first place, the action of the sun is more direct, and it is in that action that all weather changes have their origin; and in the second place, the mountain girdle of India shuts us off, in a very great measure, from the influences of the continent to the north of us, so that we need not, in general, concern ourselves with changes that may be in progress in these comparatively

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inaccessible regions. Most of our weather changes are the result of processes in operation either on the plains of India, on the surrounding mountain slopes, or on the seas which lie between us and the Equator. It is owing to these advantages that, during the few years that systematic observation has been carried on in India, we have been able to learn so much as we already know respecting the meteorology of India,—much more, I think, than we could have acquired, in an equal space of time, in perhaps any other part of the world. I shall endeavour to give you, in a condensed form, some of the more striking results, thus arrived at, with respect to the rainfall of the Indian monsoons.

In most countries, there is some one season of the year at which rain is more frequent and abundant than at others. Even in England, where, according to our familiar experience, the rain it raineth every day, there is a very decided preponderance of rain in the winter. In Central Europe, on the other hand, the summer is the season of the most abundant fall; and as Dr. Hann has lately shown, on the east coast of the Adriatic, most rain falls in November. In the tropical zone, the rainfall season is more distinctly marked, and it occurs shortly after the sun attains its greatest altitude; so that, on and near the Equator, there are, as a rule, two seasons of maximum rainfall; and in the neighbourhood of the tropical circles, the chief rain falls in the later summer months. In India, the rainy season is as distinctly marked as anywhere in the tropics; and owing to its geographical position, *viz.*, to its forming the southern extremity of a continent which reaches far into the tropical zone, the periodical rainfall extends far to the north of the Tropic of Cancer, with all its characteristic tropical features.

But although the summer monsoon rains fall more or less in all parts of India, and, in most parts, are the principal rains of the year, variations occur in different parts of the country, which are of much importance in their influence on the local agriculture; and it is only in some parts of Western India that the rainfall of other seasons is too uncertain to be regarded as a normal feature of the climate. In the greater part of extra-tropical India, the rains of the later winter months, although much less copious, are scarcely less important to agriculture than those of the summer monsoon; and more especially so in the Punjab and the upper part of the North-Western Provinces. The cause of these rains is hardly so well understood as that of the summer rains, and I shall not have to deal with them in this lecture. It will, therefore, be sufficient to observe here that they are brought from the sea by temporary winds, which, in the Gangetic Valley at least, have much the same direction as the summer monsoon, but which have neither the same volume nor the same distant

origin. In Assam and Bengal, and, to a certain extent, in the lower part of the North-Western Provinces, and in the Central Provinces to the east of Nagpore, as well as in the peninsula further south, a certain amount of rain falls also in the spring months; in the greater part of India proper, this falls chiefly in little local storms, sometimes as hail; but in Eastern Bengal and Assam it is more abundant and continuous. It begins in the latter part of March, and becomes more frequent and copious in the subsequent months, so that it eventually assumes the character of the monsoon rains, and it may be said that, in these provinces, the monsoon rains set in six weeks or two months earlier than in the more western provinces. Lastly, in the Carnatic, the principal rainfall occurs at the close of the summer monsoon. While the rains of this monsoon are falling heavily in Northern India, and on the west coast of the peninsula, the plains of the Carnatic receive but a few occasional showers; and it is not until October, when the rains are over in Upper India, and have almost ceased in Bengal, that the monsoon wind of the Bay of Bengal recurves, and blowing as an east and north-east wind on the coast of Madras, brings to that part of the peninsula the heaviest rain of the year. All these variations are dependent on the local geographical conditions, and of most of them we are enabled to give a fair account, tracing them to those variations in the course of the winds, which follow from recognized physical laws.

If the rain which, on an average, falls annually in India, were equally distributed over the whole country, it would form a sheet of water about 35 inches in thickness—a fact which we express by saying that the average rainfall of India is about 35 inches.* In point of fact, however, instead of being equally distributed over the country, the rainfall of India is characterized by inequalities greater than those of any country in the world. On the one hand, we have Cherrapunji, long renowned as the wettest known place in the world, with an annual fall which, in some parts of the station, amounts to 600 inches; and, on the other, we have such stations as Jacobabad and Sehwan, where the average does not exceed four or five inches, and sometimes, as occurred last year at Sehwan, the total rainfall of the year amounts to less than one inch.

The rainfall chart on the wall exhibits the more striking features of this unequal distribution, the average copiousness of the rainfall being shown by different depths of tint. Two narrow bands of the deepest tint, the one running up the west coast of the peninsula as far as the mouth of the Tapti, the other skirting in like manner the coasts of Burmah and Arakan, then broadening out in Bengal and Assam, and

* Omitting Lower Bengal and Assam.

again contracting to a narrow band which skirts the southern slopes of the Himalayas, indicate those regions in which the average amount of rainfall is over 75 inches. The greater part of the chart, including nearly all that lies to the east of the meridian of Cape Comorin, is covered with a somewhat lighter tint, indicating an average fall between 30 and 75 inches. Two tracts of a still lighter tint occupy, respectively, the western half of the Deccan and the Mysore plateau, and a zone of country extending from Guzerat up the Aravallis through Eastern Rajputana and the Gangetic Doab to the Punjab. In these, the rainfall varies from 15 to 30 inches. Finally, Western Rajputana, Sind, Kutch, and the Lower Punjab, are left untinted, indicating that their average rainfall is less than 15 inches in the year. The chart illustrates the distribution of the total rainfall of the year; but that which falls during the summer monsoon so greatly preponderates over that of other seasons, that a chart of the summer rainfall would differ from that before you only in unimportant details; with the exception, indeed, of the Carnatic region.

The natural processes which result in the formation of rain are essentially the same as are concerned in the process of distillation. The fire, which serves to evaporate the fluid, is represented by the sun; the boiler by the sea, and in a minor degree by every wet or even slightly damp surface exposed to the sun's rays, or to winds that have been warmed by the sun; the current of vapour down the neck of the still is respresented by the wind which carries the newly-formed vapour to the seat of the rainfall; in the case before us, by the summer monsoon wind; and finally, the worm and cooler, in which the vapour is condensed, are represented by the cloud from which the rain precipitates. Only in this last element is the parallel less strict than elsewhere; for, as we shall presently see, the cooling and condensing agency, in the case of rain-formation, is inherent to the cooling mass; not external to it, as in the case of the still. I must now describe each step of the process a little more in detail.

First, then, as regards our fire—the sun. Let us see what work it actually does in the way of evaporation. From a measurement of the sun's heat on a clear day, made by Sir John Herschell at the Cape of Good Hope, it may easily be computed that, shining vertically overhead through a clear atmosphere, the heat, if totally absorbed and used up in evaporating water at a temperature of 80°, would evaporate a sheet one inch thick in about 16 hours 25 minutes. Hence, during a day of 12 hours, with the sun in the zenith at noon, making due allowance for the varying thickness of the atmosphere traversed by its rays, the evaporation would amount to about one-third of an inch. But this supposes all the heat to be used up in the work of evaporation; whereas, in fact,

a certain portion is absorbed in raising the temperature of the sea surface, and another portion is not absorbed at all, but is thrown off by reflection; as may, indeed, be felt very sensibly by any one who sits on the deck of a steamer, in the full glare of the sun's reflection from a smooth sea-surface. What may be the amount actually evaporated is not very accurately known. From the observations of Mr. Binnie, on the evaporation of the Ambajhari tank at Nagpore, and those of Mr. Culcheth on that of a tank at Beawar in Rajputana, it appears that the loss of water, by evaporation, amounts to about one-fifth of an inch per day in the dry climate of those regions. At the Vehar tank at Bombay, Mr. Conybeare found the evaporation to be less than this, *viz.*, one-eighth of an inch; and it is probable, therefore, that on the open sea it does not exceed one-tenth of an inch daily.

At this rate, we should have about three feet of water evaporated annually from a tropical sea; capable, therefore, when precipitated as rain, of yielding 36 inches of rainfall over the same surface. Now, the area of the Indian Ocean north of the Equator, including the Arabian Sea and Bay of Bengal, may be taken, in round figures, as four millions of square miles. But, during the summer monsoon, the winds, occasionally, at least, blow across the Equator, so that the evaporating surface over which the summer monsoon blows is probably not much less than double this estimate. The evaporating surface is, therefore, ample to furnish the rain that falls on India and Burmah; since but little falls on the dry countries lying to the west of India, and there is good reason to believe that the rainfall over the sea is relatively much smaller than on the land reached by the sea winds. But the land itself also furnishes vapour; and there can be little doubt that re-evaporation of the fallen rain, and the vapour given off by vegetation, furnish a supply which is not only appreciable, but is perhaps, at certain seasons, the chief source of the rainfall. From what has been observed by Dr. Brandis in Assam, it seems not improbable that the spring rains of the upper part of that valley are mainly dependent on the local evaporation of that damp, forest-clad province. Before following the further history of the vapour thus produced, let it be noted that, although its temperature is appreciably the same as that of the water which yields it, in the act of becoming vapour, it has locked up, so to speak, as much heat as would raise nearly six times its own weight of water from the freezing to the boiling point. What becomes of this heat, and what part it plays in the movement of the monsoon, we shall see in the sequel.

Before I endeavour to explain to you the cause of the summer monsoon, which brings the vapour furnished by the Indian Ocean, to precipitate it on the hills and lowlands of

India, I must premise a few words of explanation on the subject of that oft-mentioned and useful, but much-misunderstood instrument—the barometer. The popular conception of the barometer as a weather-glass has been deeply implanted in our minds by the absurd and generally misleading words engraved on the old-fashioned dial-barometers, the form of the instrument, with which most of us became acquainted for the first time, in our early and more impressionable years. What the barometer really shows is simply the pressure of the air,—pressure, that is to say, such as is exerted by a spring or a weight, and which, invisible and impalpable as air is, is nevertheless, here at Simla, not much less than $14\frac{5}{8}$ hundredweights on every square foot of surface. At the level of the sea, or at Calcutta, for instance, it is about two-sevenths greater than this, or nearly 18 hundredweights, or $\frac{9}{10}$ of a ton on the square foot. Whatever may be the local pressure of the air, this is shown in the barometer by the height of the mercury column in the barometer tube, which that pressure supports. All beyond this, as to the actual state or prospects of the weather, is inference, which may be sound or unsound, according to the amount of knowledge we bring to bear on the question.

Now, let us contemplate one or two facts which we learn from the barometer, and which have an important bearing on the subject before us. In the month of June, the average height of the barometer column here at Simla* is 23·17 inches; at Ludhiana, in the same month, it is 28·70 inches. As the first of these measurements expresses the pressure of the atmosphere at a height of 6,953 feet above the sea, and the second, the pressure at only 812 feet above the sea level, it is obvious that the difference, *viz.* 5·53 inches, expresses the pressure exercised by that layer of the atmosphere that lies between these elevations. In other words, this sheet of the atmosphere, 6,141 feet thick, weighs the same as a sheet of quicksilver 5·53 inches thick. This, however, is true only for June, and even for that month is an average, not a constant value.

In January, the average height of the barometer at Simla is 23·34 inches, and at Ludhiana 29·23 inches, and the difference of these figures, *viz.*, 5·89 inches in like manner, expresses the average weight of this same layer of the atmosphere in that month. From January to June, this layer of air has been gradually diminishing in weight, and has lost as much of its substance as would counterbalance a sheet of mercury rather more than $\frac{1}{3}$ of an inch in thickness. At the same time, since the barometer at Simla stands 0·17 inch lower in June than in January, the atmosphere above our level has also lost in weight, but not quite half as much absolutely

* At the Quarter-Master General's Office at Portmore.

as that which lies below us. It is this variation in the weight of the atmosphere over the land surface of India which, as we shall presently see, is the immediate cause of the change of the monsoons.

But there is yet another point of view from which we have to regard the indications of the barometer. Calcutta and Madras are both very nearly at the same level above the sea, yet the pressure of the air at these two stations, as indicated by the barometer, is, as a general rule, not the same at the two places. In January it is almost always greater at Calcutta than at Madras, in June greater at Madras than at Calcutta. Now, wherever two places at the same level show different air pressures, or, what is the same thing, show different barometric readings, the air tends to move from the place of the higher to that of the lower pressure, producing a wind. And accordingly, in January, the wind blows from Calcutta towards Madras; in June from Madras towards Calcutta. In the case of stations that are at different levels, for instance, Lahore and Calcutta, a direct comparison of the barometric readings will not tell us much; but it is very easy to compute from the actual readings at any moderate height (say up to 1,000 feet) what the reading would be at so many feet heigher or lower; and thus, whatever the elevation of our stations may be, provided their difference is not greater than one or two thousand feet, we can reduce them to one common level at which we can compare them; and thus, if we have barometric readings from a sufficient number of stations, we learn what are the variations of pressure in a horizontal direction, or, as we may otherwise express it, what is the distribution of pressure on a given day, or on the average of a given month, over the whole surface of India.

In the two charts before you, this distribution of pressure is shown for the months of January and July. The blue lines, which are technically termed *isobars*, are in each case drawn through all places that have the same pressure (corrected, that is to say, to a common level, in the manner I have just described). Taking, first of all, the January chart: an *isobar* is drawn so as to include Sind and all the central portion of the desert of Bikanir. This line indicates a pressure (reduced to sea level) of 30·1 inches; and it surrounds a tract having a slightly higher pressure, on which stands the label "high barometer." The next line is supposed to pass through all places at which the pressure is 30·05 inches; the next again, through all places with a pressure of 30 inches. This runs a somewhat irregular course down the peninsula, from the Gulf of Cambay to the mouth of the Cauvery, and its course indicates that the pressure of the west coast of India, with a strip of the country above the Ghâts, Mysore, and the peninsula south of the Cauvery, is less than 30 inches. In this chart, then,

the highest pressure is in Sind and Western Rajputana, the lowest on the coast of Travancore and Ceylon; and the arrows on the chart show that, while the winds blow away from the former, they blow rather towards the latter, not directly indeed; but to this point I shall return presently.

In the July chart, an *isobar*, which represents a pressure of 29·45 inches, is drawn nearly round the Western Punjab, Bahawulpore, and Upper Sind; and the space thus included, (in which the pressure is less than that indicated by the *isobar*) is marked "low barometer," since it is, in fact, that part of India where the pressure at this season, on an average, is lower than elsewhere. The *isobars* on this chart are more numerous than on that of January, showing that greater differences of pressure exist; that with the highest value, *viz.*, 29·85 inches, just cuts off a little bit of Ceylon and the coast of Travancore. It is here that the pressure is highest (as far as is shown on the chart); and, accordingly, the winds indicated by the arrows blow away from this, and following a somewhat circuitous course, tend towards the Punjab and Upper Sind. Further south and west on the open sea, the pressure is still higher than on the coast of Travancore, and the south-west or *summer* monsoon (as I prefer to call it) blows from this tract of high pressure to the tract of lower pressure over India, and terminates at the seat of lowest pressure in the Punjab.

That the wind should blow from a place where the pressure is high, and towards one at which it is low, may be understood without much difficulty; but now we have to consider the question, "what causes these variations of pressure?"—a question which must be answered before we can be said to understand much about the monsoon, or the rain which it brings us. The sun shines with equal intensity on land and sea; but the temperature of the land and the wind that blows over is not the same as that of the sea. In the hot weather the sea-breeze is a cool breeze; in the cold weather the land wind is the cooler. In a well-shaded place on a steamer in these seas, and during calm weather, there is a difference of only 5° or 6° between night and day. But in the Punjab (which one may take as a good illustrative instance, because the climate is dry, and it lies far from the sea), this difference is often 30°, and sometimes as much as 40°, and even more. Now, these differences are partly due to the fact that the materials of which the land consists, earth and stone, are both heated and cooled much more readily than water. In fact water requires four or five times as much heat to raise its temperature, say 1°, as do stone and earth; and if, therefore, both are exposed to the same source of heat, the water requires four or five times as long to become heated as the materials that form the land; and the same to cool.

Further, a great part of the solar heat that falls on the sea surface is used up in evaporating it, but on the land very little of the heat is so utilized. It is absorbed by the ground and then stored up, whence by degrees it is given off again to the wind that sweeps the surface. So much is this the case, that I find that, on the average of two years, the temperature of the ground of Calcutta, at 3 feet deep, is not less than 5° higher than that of the air; and, in like manner, Mr. Broun found, at Trevandrum, an average difference of 5·7° between the ground temperature at 3 feet depth and the air.

There is yet a third reason why in the summer the heat of Northern India should become excessive. The quantity of solar heat received by any place depends both on the height of the sun and on the length of the day. In respect of altitude, the sun is, of course, hottest, when it shines *directly* overhead, and this is the case at places on the Tropic of Cancer on the 21st June. But since the days become longer in summer as we go further north, it results that, on the average of the summer, from the 1st May to the 15th August, more heat falls on the zone between 30° and 40° north latitude, than on any other part of the globe.

It is herein that we have the primary cause of the summer monsoon, and therefore of the rain. The Punjab is that part of India which, on the average of the summer, receives most of the sun's heat; and since it is a very dry region, and comparatively cloudless, this heat serves mainly to heat the ground and the air resting on it; and accordingly, as our temperature registers show, in the latter part of May and in June, the heat of the Punjab surpasses that of any other part of India.

Now, the effect of heat on the atmosphere is to expand it. The consequence is, that as the lower strata of air (which are those most heated by contact with the land) are gradually warmed up from January to June, they expand and lift all the super-incumbent higher strata of the atmosphere, somewhat as the expanding springs of a gigantic spring mattress might do. These higher strata, thus lifted, partly flow away towards some cooler region, chiefly towards the winter hemisphere; and the result is, that the pressure of the air over India, and especially over the Punjab, falls.

You will now understand why the stratum of air between the levels of Simla and Ludhiana weighs less in June than in January. It is much hotter, and, being expanded by heat, less dense. You will also understand why, at the sea level in June, the pressure of the air is less in Bengal than at Madras, and least in the Punjab. The pressure is least when the heat is greatest. The chart before you, which represents the distribution of temperature and, in part, of pressure on one of the hottest days in May 1879, serves to illustrate this.

I will now briefly recapitulate what we have just learned respecting the cause of the summer monsoon; *firstly*, during the spring and earlier summer months, the land of India becomes more rapidly heated than the sea, and very speedily acquires a higher temperature, which it retains till late in the year. This arises, partly from the fact that the materials of which the land consists are more rapidly heated than water, in the proportion of 4 or 5 to 1; partly because much of the heat that falls on the sea is used up in evaporating it, whereas very little is so consumed on the land. The Punjab is the seat of the highest temperature in India, partly because it is a very dry region, but principally because, on the average of the summer months, the zone of the earth in which it lies receives more sun's heat than any other; *secondly*, the seat of highest temperature becomes also the seat of lowest atmospheric pressure, or the region where the barometer shows the lowest reading. This is because the lower strata of the atmosphere, and more especially the lower 6,000 or 8,000 feet, expand as they are heated, lifting up the higher strata, which then partly flow away towards cooler regions; for precisely the same reason that if one end of a trough of water is lifted, a part of the water flows from the higher to the lower end; and, *thirdly*, the air at the sea surface moves from where the pressure is highest, that is, in the neighbourhood of the Equator, or rather to the south of it, to where the pressure is lowest, *viz.*, over India, and especially towards the Punjab. Such is the explanation of the second part of our subject, *viz.*, why the summer monsoon brings to India the vapour that has been produced in abundance over the seas which stretch away to the southward.

Before passing on to the next part of our subject, I must, however, draw your attention to one point, in which you may have observed that the evidence of the wind charts of January and July, which are before you, does not exactly accord with the description I have given. You will have noticed that the *winds in January do not blow directly away from Western* Rajputana or Sind, which is then the seat of highest pressure, nor in July do they blow *directly* towards the Punjab, which is then the seat of lowest pressure. On the contrary, their course is very circuitous. In January they rather blow spirally outwards, circulating in the same direction as the hands of the clock move; and in July they blow spirally inwards, the circulation being of the opposite character, or against the movement of the clock hands. Thus, in July, the winds on the west coast of India are nearly from west, not from south, and the same in the Central Provinces. And on the Bay of Bengal, they are from south-west, not from south-east, which would be the direct course towards the Punjab; while, in Lower Bengal, they are south, and only in the Gangetic Valley south-east or more easterly.

This circuitous course is, in both cases, the consequence of a law which an American mathematician, Mr. Ferrel, has shown to apply universally to all bodies moving on the surface of the earth, and which is now known as Ferrel's law. It is in consequence of the earth's revolution on its axis that rivers, railway trains, winds, indeed everything that moves over the earth's surface, tends to deviate to the right in the northern hemisphere; to the left in the southern hemisphere. A train moving at the rate of 50 miles an hour, say in latitude 30° north, presses against the right rail, with an accelerating force of $\frac{1}{16}$th of an inch per second, when running on a perfectly straight part of the line. And this pressure varies directly as the rate of its movement, increasing with the latitude, so that, while it is zero at the Equator, it reaches its maximum at the pole, where it would be exactly double as great as in latitude 30°. It is probably partly in consequence of this law that rivers generally tend to hug the right side of their valleys. Thus, the Indus flows nearer to its mountain barrier than does the Ganges; that of the former being on the right, that of the latter on the left of its course. There are doubtless other and more powerful causes at work in these cases which are geological, and have nothing to do with the earth's rotation; but still this influence is not without its effect.

Now to return to the winds. You can easily see that, if a number of wind-currents are radiating in several directions outwards from a region of high pressure, and all tending to deviate to the right, the result will be a spiral circulation with the hands of the clock. And, on the other hand, a number of wind-currents, flowing radially inwards towards a place of low pressure, will move, not directly towards it, but to the right of it; and their movements combining will produce a spiral movement inwards of precisely the opposite character to the former. Thus, then, is explained the actual movement of the monsoon, such as it is shown to be on the chart before you.

Having now considered the production of the vapour which furnishes our rain, and the cause of the wind movements which bring it to us, it remains to notice the actions which condense it and precipitate it as rain. At a first glance, it seems not a little paradoxical that, having reached the hottest part of the earth's surface, it should there be condensed; seeing that, in order to condense it, it must be cooled, just as the steam produced in a still is cooled and condensed by being passed through the worm, which is surrounded by cold water. And this is really only a part of the paradox. For, in the act of condensation, the vapour must part with all that heat which, as I have told you, becomes locked up in it in the act of becoming vapour, and which would have sufficed to raise it nearly six times over from the temperature of ice to that of boiling water. Yet, not only is this heat got rid of, but it is precisely this which makes

the summer monsoon so much stronger and steadier than the opposite or winter monsoon. The solution of this paradox, which we owe mainly to the discoveries of Clausius, Joule, and Sir William Thomson, is perhaps one of the most beautiful applications of a physical law to the explanation of atmospheric phenomena which meteorology furnishes.

A few moments' consideration will convince us that the air, which the monsoon pours into India from both coasts, can only pass away by rising more or less vertically upwards, and flowing off in the higher strata of the atmosphere, which are beyond our field of observation. The mountain barrier on the north and west—and which in the former direction is so high as entirely to shut in the lower half of the atmosphere—prevents its escape in any horizontal direction. It *must* rise, therefore, some 8,000 or 10,000 feet, in order to escape to the westward, and not less than 18,000 or 20,000 feet to escape to the north. And if we suppose that it flows back again to the south as an upper current above the monsoon, we have reason to believe, from certain barometric observations on the mountains of Ceylon and on the Himalaya, that the monsoon current is not less than 10,000 or 12,000 feet thick, so that in any case there is no outlet for the air at any lower elevation.

Now, as air ascends, the pressure of the atmospheric strata above it is constantly diminishing. We know that, while the barometer at Ludhiana in June shows an average pressure of 28·7 inches, at the height of Simla it shows a pressure of only 23·17 inches. In rising, therefore, from the lower to the higher level, it comes under a pressure between one-fifth and one-sixth less than it was subject to originally; and just as a spring extends when relieved of the pressure, which keeps it down, so air expands under these circumstances. But while expanding it has to make room, so to speak, for the increase of volume, and therefore it must raise or thrust aside the air which presses upon it. In order to do this work, it draws on its own store of heat. If it is dry air, it can only draw upon that heat which gives its warmth. In other words, it cools; and from Joule's very accurate experiments we know that it must cool on one degree Fahrenheit for every 186 feet of rise. If, however, like the summer monsoon wind, it is charged with vapour, it cools at this rate only until it has reached the temperature at which it begins to condense its vapour and form cloud; and it then draws partly upon its own warmth; but still more upon that heat which was locked up in the vapour, and which I have more than once referred to. A cloudy atmosphere, in ascending, cools, therefore, more slowly than a clear atmosphere; in this case the rate varies with the temperature and the pressure; but we may take it, in the case of our monsoon, at one degree for 400 or 500 feet.

The flat-bottomed masses of clouds, with rounded piled-up summits, which are so common in the daytime over the plains of India, more especially in Bengal or in the Upper Provinces, when a light, damp wind from the eastward is bringing vapour from the direction of the sea, are an illustration of this action. The lower atmosphere is then rising, not *en masse*, but partially and locally, chiefly below the cloud. The flat base marks the level at which the air is first cooled to that point where the vapour begins to condense; and, as we know from the observations of Welsh and Glaisher, in their balloon ascents, the temperature decreases upwards, more slowly in a cloud than in the clear, cloudless atmosphere below it.

Again, in these hills, when a strong damp wind is blowing up either from the Sutlej Valley on the north-west, or from the Giri and its tributary, the Ussan, on the south-east, you may often see that, above a certain level, the air on the windward side of the ridge is thick with cloud. If seen from a distance, the cloud appears to be motionless. But near at hand, you may watch it carried up with the air current over the ridge, while new cloud is constantly formed at its base; and if, as sometimes happens, it is sinking on the side of the ridge, below a certain level, the cloud dissolves away. Such illustrations of the formation of cloud by ascending air and its absorption by descending air, are common in the hills.

In all cases, heavy rain indicates that the air from which it is precipitated is ascending. Generally below the cloud the air is calm; or, at all events, the wind is light: but air around must be pouring in to feed the rain; and thus we find that, between the region of heavy rainfall and the sea, a strong wind is blowing so long as the rain continues.

We may now turn our attention once more to the rainfall chart of India, which I described briefly at the beginning of this lecture. I then pointed out to you some of the more striking features of the rainfall distribution as shown on the chart, but left their explanation unattempted. With the knowledge which we now have of the physical actions which determine the formation of rain, we may contemplate these features with a more intelligent eye, and we can see how they result from the well-known geographical peculiarities of the country, in conjunction with the course of the winds. Here, for instance, on the west coast of the peninsula, is a zone of copious rainfall, bounded by the Western Ghâts; on some parts of which, as at Mahableshwar and Matheran, the annual average is not less than 250 inches. Within a few miles of the crest to the eastward of the Ghâts, the rainfall rapidly diminishes, so that, at Poona, it is only 31 inches, and the Deccan plateau, which stretches away to Sholapore and beyond, has an average of considerably less than 30 inches.

The wind from the Arabian Sea blows on the west coast from almost due west. Within 50 or 60 miles of the coast line, or even less, it meets the mural face of the Ghâts, to cross which the air must ascend at least 2,000 feet; and at some points, such as Mahableshwar and Baura fort, considerably more. Here then is the heaviest rainfall. But the ascent is not restricted to the face of the Ghâts. More or less, it is taking place over the whole breadth of the Konkan and Malabar, and hence the rainfall of all this strip of country is excessive. But having crossed the crest of the Ghâts, and having thus parted with a large proportion of its vapour, the wind descends, following the slight slope of the country. The geographical form of the country is, therefore, unfavourable for precipitation, and the rainfall is much below the general average of the peninsula. As we approach the opposite coast, we meet with the hilly country, which includes some plateaux of considerable height; and here again, the rainfall is higher, and some is also received from winds which, both in the spring months, and also at the close of the summer monsoon, blow from the Bay of Bengal.

The Arakan coast borders the foot of a mountain range higher than that of the Western Ghâts, and here again, therefore, we meet with a copious rainfall—that of Sandoway, for instance, exceeding 200 inches, while that of Akyab is but slightly less. But the wettest region of all is the south face of the Khasi Hills, which rise precipitously from the low inundated swamps of Sylhet. Cherrapunji, on the crest of this escarpment, has a rainfall which may be said to average more than 500 inches; while some registers, kept in earlier years, nearer the edge of the scarp than is the present rain-gauge station, showed an average of 600 inches. The position of this station is eminently favourable to the precipitation of rain. Up to the very face of the escarpment, the winds from the Bay sweep over an inundated country, and arrive saturated with vapour. The little sand-stone plateau, on which the station stands, forms a sort of peninsula, communicating by a narrow neck with the mass of the hills to the north, being enclosed between two gorges which debouch on the plains, and are terminated at their upper extremities by precipices of 2,000 feet sheer drop, over which fall the cataracts of Mawsmai. Blowing up these gorges, the air ascends vertically over the margin of the plateau; and being thus surrounded by vertically ascending currents, the deluge which pours down on the station is such as, as far as we know, is unparalleled elsewhere.

Time does not allow me to enter into an explanation of the variations exhibited by most other parts of Northern India; but I cannot quit this part of the subject without a few words in explanation of the dry desert tract which

borders the Indus, including Sind, Bahawulpore, and Western Rajputana.

The monsoon wind in Sind blows mainly from the southwest or south, following the line of the Indus. But the fact that, on the Arabian Sea, the winds are rather west than southwest, leads us to infer that this wind does not come direct from the sea, but is largely recruited with air from the dry Gwadir coast; and indeed, were the mountain ranges which bound the Indus Valley on the west effaced, the law of the winds indicates that it would be entirely derived from Beluchistan. It contains little vapour, and, accordingly, rain falls in Sind and on the hills chiefly, when the wind blows from the east; and this occurs but rarely. It is then the geographical position of Sind, having an exceedingly dry country to the westward, together with the fact that the seat of lowest pressure usually lies to the north of it, in the Punjab, that renders Sind comparatively rainless.

Before I conclude, you might expect that I should say a few words on the irregularities of the monsoon rains, those seasons of drought or of local drought and local flood, of which we have had so many disastrous examples during the last few years. I should be, indeed, only too rejoiced could I give you as satisfactory an account of the causes of these irregularities as I have endeavoured to give you of the normal features of the monsoon rains. But the five or six years, during which we have been able to watch and take note of these vicissitudes of our seasons, are far from sufficient to do more than suggest points for future inquiry; and anything that I can say upon this subject will be of a very fragmentary, and, I fear, unsatisfactory character.

It is obvious that many different causes might be imagined to cause a diminished rainfall. For instance, diminished evaporation, arising from a deficiency of solar heat, or a decrease in the volume of the vapour-bearing monsoon, such as might ensue from a large part of the air from the sea being drawn in some other direction, or, instead of being drawn away towards the land, remaining comparatively motionless and condensing its vapour over or near the place of its production; or, one might imagine that, owing to some derangement in that series of processes by which the distribution of pressure is usually determined, that distribution might be so modified that less air should be drawn from the sea and more from the dry land region. It is quite possible that one or all of these suppositious causes may play their part, and indeed there is little doubt that, to some extent, they do so. Thus, in 1876, the year of the great Madras and Deccan famine, there was an unusual northerly tendency in the winds all down the peninsula; and during the present year, the Bombay monsoon has been usually deficient in vapour, whether owing to the

restriction of the area of evaporation or other cause. But although even such partial explanations are not without interest, they are at least but a first step, and a very small one, twowards such an explanation as may enable us, to some extent, to foresee calamities arising from drought and flood; and their chief value is, that as far as they go, they represent an observed association of facts, the meaning of which our knowledge of physics enables us to appreciate, and they may therefore serve as stepping-stones towards some wider generalization. Of a very different category is the hypothesis, which has been so frequently brought forward of late years, that the rainfall varies with the spottiness of the sun's surface. This phenomenon is now known to go through a regular cycle of variation or, more probably, more than one periodical cycle, but *certainly through one, the duration of which is about 11 years.* Now, as regards the average rainfall of the world as a whole, I think that the very extensive mass of evidence collected and discussed by Mr. Meldrum, of the Mauritius, does show very good *primâ facie* reason for the truth of the view which he originated, and has most conscientiously worked out. Taking the average from year to year of a great number of stations in America, Europe, Asia, Africa, Australia and some islands, it does appear probable, that the rainfall, about the time when the sun is most spotted, is about fifteen per cent. greater than when it is least spotted. But when we restrict our view to a single country, or group of stations, it is difficult to detect anything like a distinct cyclical variation amid the much greater variations that follow no such law. It is true that, from 1863 to 1876, the rainfall of the Carnatic did seem to conform to something like a regularly progressive cycle of variation, not differing very greatly from that of the sun spots. From 1863 to 1868 the rainfall of this province was below the average, and most so in 1867, in which year also the sun spots reached their minimum. From 1869 to 1874 *it was above the average, with a maximum in 1872, or about* $1\frac{1}{2}$ years after the sun spot maximum; and it was again below it in 1875 and 1876; very greatly so in the latter year. So far then, the accordance, although not exact, was sufficiently striking; since in 1876 the sun spots were rapidly approaching their minimum. But the sun spots were decreasing till the early part of 1879, whereas the Carnatic rainfall of both 1877 and 1878 (more especially the first of these years) was considerably above the average. The Carnatic is the only province of India in which I have been able to trace anything like this cyclical variation; and even here it is evident, that if the accordance be more than a mere fortuitous coincidence, it is too uncertain to be made the basis of a forecast.

As to the nature of the supposed connection between the state of the sun's surface and the rainfall of the earth, we must

admit that we know nothing. Even the fundamental point, whether the sun is hottest when most or when least spotted, is one on which you will find those, who have paid some attention to the subject, to hold the most opposite opinions. Such observations as have been made directly on the intensity of the heat emitted from the sun, seem to show that the sun is hottest when most covered with spots; but on the other hand, when this is the case, it appears that the temperature of our atmosphere is lowest, and that it is highest about the time that the sun has fewest spots. Until some way of reconciling these apparently conflicting observations has been found, it is obviously premature to form any judgment on the question of the relation of the rainfall to the solar variation. If Mr. Meldrum's view be accepted, that the rainfall varies directly as the quantity of the sun spots, it would accord with the result of the direct observations on the heating power of the sun; because we might expect that the hotter the sun the greater would be the evaporation from the sea surface, and the greater therefore the rainfall; but this question, like many others, must await further experience.

There is one class of facts which may perhaps be of some utility in enabling us to some extent to frame forecasts of our seasons in India, to which I may briefly refer, although their connection with the monsoon rainfall is little more than a tentative hypothesis. On many occasions it has been noticed that, when the winter or early spring rains have been unusually copious, and especially when they have been late, and have been accompanied with an unusual fall of snow on the Himalaya, the rains of the Upper Provinces and Rajputana have been either very deficient or much retarded. The first occasion on which I noticed this, was in the famine year 1876, which was preceded by abundant and late spring rains on the Upper Provinces with an unusual amount of snow on the mountains of Kashmir. A still heavier fall of snow on the Himalaya characterized the winter and spring of 1876-77; and, as will be remembered by many of you, the monsoon rains failed almost completely in the North-Western Provinces in that year. In the spring of 1878, the spring rains began late, *viz.*, in April, and lasted through the greater part of May, and much snow fell on the higher ranges. In this year the rains were only retarded, but they did not set in till the beginning of July, and were deficient in the Upper Provinces even in that month, and it was not until August that rain fell abundantly in North-Western India. Last year, 1878-79, both the winter and spring rains were remarkably deficient, while the monsoon rainfall was abundant. In the present year, both the winter and monsoon rains have been deficient, although there was good deal of cloud and rain in April and May, but the meteorology of the present year has yet to be

worked out. It is, however, a noteworthy fact that in July, as I was informed by Major Biddulph, the rain and snow on the mountains of Northern *Kashmir* were very unusual, and such as are unprecedente dduring the four years over which Major Biddulph's experience extends; and it will be within the recollection of all, that the month of August has been almost rainless in the Punjab, the North-Western Provinces, and Rajputana. Although then it would be perhaps unreasonable to look to this snow precipitation as the sole, or even perhaps the principal, cause of the failure of the monsoon rains in North-Western India, there seems good *primâ facie* reason to regard it as an influential cause.

Seeing for how few years we have been able to investigate the meteorology of India with anything like system, I think that these glimpses of light, few and feeble as they are, are fraught with promise for the future, and I look forward with confidence to a time, when some successor of mine shall be able to give you as fair an account of the causes that disturb and interfere with the regular and beneficial course of our seasons, as I have endeavoured to give you this afternoon of the ordinary normal production of our rainfall.

Iron-making in India.

(From the "Englishman" of July 14th, 16th, and 17th, 1880.)

Now that the Afghan war is drawing to an end, it may be expected that the material progress of India will again engage the attention of the Indian Government. As a means of famine prevention, the development of industrial enterprises is to be ranked with, if it should not take precedence of, irrigation works and railways; and among such enterprises none, perhaps, holds out fairer prospects than that which has contributed so largely to British prosperity—*iron manufacture.*

Everybody knows that there is iron ore in many parts of India, but it is not generally known that in Central India there are ores of that metal of the best quality.

The Central India iron ores are remarkable at once for their purity and their richness. They are chiefly red iron ores and magnetite, containing sometimes manganese, but there are also brown iron ores and siliceous hematite. As all these ores occur in enormous quantities on the surface of the ground, the erection of costly mining works, which is elsewhere necessary, is here not required. Owing to the *difficult treatment required* for the magnetites, the native iron makers prefer the soft red ironstones of a laminated texture, although the former contain a larger percentage of iron. The brown iron ores and the siliceous hematites are used by them only very exceptionally.

Before showing how the Indian iron ores may be utilised without prejudice to English interests, we will give an analysis of the iron ores of Central India, together with some other details.

The magnetites contain 71 per cent. of metallic iron (or 69 per cent. oxyde, and 29½ per cent. protoxyde of iron), the red iron ore from 65 per cent. to 69 per cent. of iron (or 94 to 98 per cent. of oxyde of iron), the brown iron ore 45 to 55 per cent., and the siliceous hematites 40 to 48 per cent. of metallic iron. The few impurities of these ores are small quantities of quartz, clay, and manganese, and exceptionally some lime; of sulphur there are but few traces; of phosphorus none :—at least none have been discovered in the red iron ores and in the magnetites.

So much has the exceptional purity of these ores struck observers that somebody, writing of them in a public paper some time ago, maintained that they were pure iron, which is incorrect ; the richest iron ores can never contain more than 72 per cent. of metallic iron. Iron always occurs in nature combined with oxygen, the lowest degree of oxydation being in magnetite. Pure iron might perhaps be said to occur in meteors, but here also it is combined with nickel from 3 to 8 per cent. We know of no ores in the world which are fully equal to those of Central India in purity, in richness, and quantity over a given area. The red iron ores of Whitehaven in Cumberland, the specular iron ores of Elba, the magnetites of Danemora in Sweden, and of Blodogat in the Ural mountains, are precious indeed, but they are found in smaller quantities, and have generally to be quarried from great depths, often many hundred feet, by means of expensive mining establishments, whilst here, by simple surface digging, we may say that immeasurable quantities of the stuff are to be obtained.

In general the European iron ores contain only from 30 to 35 per cent. of metallic iron, therefore half only that contained in the red iron ores and in the magnetites of Central India. How great a value is put on pure and rich ores by iron makers may be learned from the circumstance (which should be made widely known in India) that vast quantities of such ores are yearly imported into England, France, Germany, and Belgium from the south of Europe and more distant countries. In 1878 Bilbao, in Spain, shipped 1½ million tons of iron ores to Cardiff. Herr Krupp, the great gun-maker of Germany, has his own iron mines in Bilbao ; France draws yearly 500,000 tons of iron ore from Mokta in Algeria, and England also imports large quantities from the same source. The exported ores of Bilbao are brown iron ores with 52 to 55 per cent. of metallic iron ; those of Algeria are magnetite and red iron ore with 60 per cent. of metallic iron ; the Bilbao and Algerian ores are therefore from 10 to 15 per cent. inferior to the same kinds in Central India.

The iron ores of Central India containing, as was said before, no phosphorus and little manganese, are suitable for the production not only of bar iron, but notably also of steel, and especially of Bessemer cast-steel for rails.

It is well known that the amount of phosphorus in the ore determines its fitness for the Bessemer process; and if it exceeds $\frac{3}{4}$ per cent. the steel cannot be converted into rails, which are now generally made of Bessemer steel.

Again, ores containing manganese are known to be especially useful for the production of steel for cutting tools. Equally suitable are the pure red iron ores of Central India, containing manganese, for the production of "Spiegeleisen" (specular cast iron) a kind of pig iron, which he added to the iron in the Bessemer process, and in cast steel crucibles. Great quantities of this article are exported from Germany and Austria, and the price of it is 60 per cent. higher than that of ordinary pig iron. The same is the case with an article called in the trade *acier sauvage* (wild steel), also a kind of pig iron, containing a very small quantity of carbon. This is exported at high prices, from Styria in Austria to England, France, and Belgium, for the manufacture of ductible iron for wire. Now "Spiegeleisen" and *acier sauvage* can only be obtained from the *purest* iron ores, and of these there are inexhaustible mines in Central India. Here we have then a most valuable raw material for exportation which would not interfere with England's commercial policy as regards India, which has hitherto consisted in the principle of taking India's raw produce and returning it to her in the shape of manufactured goods.

Should the art of iron-making in the course of time be so far developed as to furnish us with an economical process of making finished iron or steel direct from the ore, that is to say, without the introduction of the blast furnace and fining process, then pure ores would greatly increase in value and become eventually a most important article of export from India.

The following explanation of the present system of iron-making will show the importance of the exertions which are now being made towards the obtaining of iron by a *direct* process.

The object of the blast furnace-process is, first to free the ore from oxygen, then to induce carbon into the article so obtained, and, finally, to melt this compound. The product of the blast furnace is thus iron with a greater or lesser percentage of carbon, called pig iron. The next, namely, the fining process, has for its object, on the contrary, the freeing of pig iron from carbon, or the production of a metal free, or nearly free, of carbon. To the uninitiated the question will at once present itself why these opposite processes are followed—why the reduced ore, *i.e.*, the ore freed from oxygen, is not melted down direct into iron in the blast furnace instead of first infusing it

with carbon, and then freeing it from the same by the expensive puddling or Bessemer process.

The reason is two-fold : first, because it is difficult to melt down pure carbonless iron. It would require a heat of 1,700° centigrade, whilst pig iron, or iron containing carbon, melts with a heat of from 1,100° to 1,400° centigrade, and it is this excess of from 300 to 500 degrees of heat which is difficult and expensive to attain, both as regards fuel and fire-proof material for the furnaces. The second cause of the round-about process is the more or less impure state of iron ores, especially in respect of phosphorus and sulphur. Opportunity and time for departure must be given to these impurities, and this is done by the repeated melting and manipulating of the stuff in the so-called fining process.

From this short explanation the reader will easily perceive that, in the case of the magnetite and red iron ores, in which we have to deal with either very small or inappreciable quantities of impurities, the question of producing pure iron or steel by a *direct* process is reduced to one for the science of heat to solve. It is a question, in fact, of producing 1,700° centigrades of heat economically. The solution of this question is approaching. The efforts of Siemens, Dupuis, and others in this direction, if they have not solved this problem, have at least paved the way to its solution. But it may be objected that the best iron ores and the largest quantities of them in Central India are of no avail, as there are no coals there ; the reply to this objection is, that there is ample wood available. But it may be again objected, as was indeed done a short time ago, by a writer in the columns of a daily contemporary, that making iron in India with charcoal has been tried and has failed. It is well known, however, that excellent iron has been made in India for centuries with charcoal. Those also who know anything of the iron trade know that vast quantities of iron are made in Sweden and Styria, both for home consumption and for export, with vegetable fuel. It cannot be that the price of charcoal in India is an obstacle, since it is about three times as high in Styria, for instance, as in India ; neither can the failure have been caused by the experience of charcoal making bad iron, for the reverse is well known to be the case. The true cause is not far to seek ; it can have been due to nothing else than to ignorance, or bad mechanical arrangements, or bad management, or dishonesty, and very likely to all these combined.

Having said so much on the question of producing iron from the ore by means of vegetable fuel in general, we propose another day to examine the question in detail, since it is on this question of vegetable fuel *versus* mineral coal that the future iron industry of India must be decided.

The chief advantage of wood and charcoal over mineral coal, as a fuel, consists in the greater purity of the former.

This circumstance alone is of incalculable value in iron-making. Mineral coal contains from 6 to 25 per cent. ashes and a greater or less quantity of sulphur, both, as stated before, injurious to the production of iron. Much ashes make the work unclean, fill the furnaces with slag, produce smoke and dirt, which are the bane of the workman and a nuisance to the neighbourhood of an ironwork. The sulphur ingredient of coal is burned into sulphurous acid which renders the iron brittle, not to mention that it makes the work highly unpleasant and unwholesome. Wood contains but from 1 to 1½ per cent. of ashes, and never any sulphur; iron, therefore, produced by wood and charcoal, not only escapes contamination but any impurities which may be in the ore are to a great extent expelled from it.

The price of iron made with vegetable fuel is, for the reason *just explained, very much higher than that of iron made with* mineral coal, indeed often two and three times higher. Charcoal iron from Danemora in Sweden has been known to fetch in Sheffield £14 per ton at the time when English iron (made with mineral coal) was selling in the same place at £6 per ton. In Germany charcoal pig iron fetches 170 shillings per ton, against 75 to 80 for mineral coal pig iron. The same relative prices prevail in other iron-manufacturing countries. How great a demand there is for good charcoal iron, may be inferred from the fact that 90,000 tons of it are yearly exported from Sweden, one-third of which is taken by England. That more of this material is not exported from Sweden is due to the fact that the production of it is purposely checked for fear of lowering prices.

The only apparently valid objection which can be urged against iron-making on a large scale with wood and charcoal is, that it might lead to the destruction of forests, the preservation of which is so important on national, economical and sanitary grounds. To this objection must be opposed facts apparently paradoxical, yet perfectly true, namely, that it is in those countries *in which the iron industries are carried on* with wood and charcoal, that the forests are in the most flourishing condition. Whoever has travelled in Sweden, in Styria, or in Carinthia, could not but have been struck with the great extent and the magnificent appearance of the forests. This pleasing sight is entirely due to the great development *of iron industries in these* countries, and to their being carried on by means of wood and charcoal.

Sweden has 250 blast furnaces, and the Austrian crown lands of Styria and Carinthia have 60 blast furnaces worked with charcoal. The fact is that the great demand for vegetable fuel, having greatly enhanced the value of forests, has given rise to a most careful treatment of them, and to a highly *scientific system of artificial forest culture.*

Sweden has no mineral coal, and it may be said also comparatively little agriculture. She nevertheless enjoys great national prosperity, which she owes entirely to turning to good use *her fine forests and her superior iron. Those who are* unacquainted with the manufacture of charcoal in large quantities may think that there must be a great waste of valuable timber connected with it. This need not be so, as all the valuable parts of trees may be reserved as timber.

In Europe it is calculated that a forest of average condition and under systematic management will yield yearly 800 tons of wood per English square mile, and that the trees felled will be reproduced every fifty years. Now, the production of 12 tons of finished iron per day by means of wood and charcoal would require yearly about 40,000 tons of wood, or the yearly produce of 50 English square miles of forest. But not far from the localities where the best iron ores occur, there are also forests (situated on a plateau elevated about 1,200 feet above the level of the sea) covering 2,400 square miles. These forests may be counted upon to yield 15,000 tons of wood per square mile, or about 56 million of tons for the whole area, and would *therefore suffice to feed an iron work producing* daily 12 tons of finished iron during nine hund red years, in which calculation the question of recoupment by natural growth and artificial planting has not been taken into account. If natural growth and artificial planting be taken into account, these forests can feed 40 blast furnaces for an indefinite period without being exterminated.

Besides the above forests there are in more distant districts other sources of wood to which these ores, owing to their excellence, would bear the expense of being carried in order to be melted down, especially if the railway tariff for goods in India were lowered a little, particularly for iron ores.

It may be here explained, for the benefit of the uninitiated, that iron ores are always carried to the fuel, and not the fuel to the ores, as, for the production of a given quantity of iron, a greater weight of fuel is required than of ore, especially when the ore is so rich in metal as that of Central India; besides that, owing to the smaller bulk of ore for a given weight compared with that of wood, the ore can under all circumstances be carried cheaper, and larger stores of it can be more conveniently kept.

There are very great varieties of wood in Central India, and most of them are hard woods, which makes them all the more precious for smelting purposes, as the quality of charcoal is proportional to its specific weight, and the harder the wood is the greater is the specific weight of the charcoal made *from it.*

It may be not unimportant to mention here that the method employed by the natives of India in the production of charcoal

is, to say the least of it, very primitive. They lop the branches off the trees and leave the trunks to their fate, or burn them and use the ashes as manure. With all this waste, native charcoal is well burnt, specifically heavy, and astonishingly cheap; near the forests it may be had at the rate of As. 4 per maund. Its weight is 17lb. per cubic foot. The German and Styrian iron works pay As. 12 per maund for charcoal weighing only 12lbs. per cubic foot, an article therefore of a quality nearly 40 per cent. inferior to that of Indian make and three times as dear.

Trusting that iron-making by hand in India will soon be counted among the things of the past, we may be allowed to record its method briefly :—

The whole arrangement, furnaces and tools, are exceedingly poor and petty; the smelting furnace is a shaft of clay, 1 foot square and 3 feet deep; this shaft is entirely filled with charcoal, and a charge of 40lbs. of iron ore is heaped up above this—then the lighting and blowing commences. The bellows consist of two cylindrical leather bags, which are pressed down alternately, whereby the compressed air is driven in a continuous stream into the oven through funnels of clay, situated about 9 inches above the bottom of the furnace. After a couple of hours blowing and several replenishings of charcoal, the smelting process is complete, when the master of the work draws from the bottom of the furnace with a pair of tongs an unshapely lump of iron (called in the vernacular "Lotah") weighing from 18 to 20lbs.,—this is then dragged to the front of the building, when it is beaten with hammers till it is reduced to a disc of 6 to 8 inches in diameter and 2 inches in thickness. As the natives add nothing to the ore in the furnace, the loss of metal through slagging is considerable. In this manner the work is continued ceaselessly for 24 hours, after which the furnace requires repairing. During this time four labourers and one master are employed, the latter generally the owner of the establishment. The labourers relieve one another at the bellows, the master being employed in removing the "Lotah" as said before, and in mending the oven and funnels. These five men earn together during the 24 hours Re. 1-1, and turn out in this time two maunds of half-finished iron.

The refining and finishing processes are carried on in rough open forges, and the articles manufactured are horse shoes, spades, cramps, and other small objects. In the production of 1 to 1¼ maunds of finished goods (in 24 hours) there is a waste of 40 or 50 per cent. of iron, the consumption of fuel being three maunds. Six men and four boys work at two forges, and earn in the aggregate Rs. 1-12. Therefore, for the production of 1 to 1¼ maunds of finished goods from the ore (in 24 hours) there are employed 5 men in producing two

maunds of half-finished iron, and 6 men and 4 boys in converting this into 1 to 1½ maunds of finished goods, or altogether 11 men and 4 boys, who earn Rs. 2-13. The total consumption during this time is of charcoal 9 maunds and of ore 4½ maunds. The same quantity of iron goods made with the present European appliances would consume but ⅓rd of fuel and ½ of ore.

Notwithstanding the simplicity of these processes, the iron turned out by the natives is of superior quality, and is selling very cheaply; so, for instance, a maund of horse shoes sells at Rs. 8 and of cramp-iron Rs. 6-8. These low prices are accounted for by the cheap fuel, the rich ores, the miserably cheap labour, and the absence of managing expenses.

As regards the fitness of the native iron worker and the native in general for European iron works, it must be admitted that he is for the present not so powerful or persevering as the European workman, but his strength and energy would improve with more plentiful and more generous diet, the means for which would be furnished him by the superior wages which industrial establishments conducted on European principles could afford to pay him.

We will now consider somewhat more closely the commercial side of the question of iron works in Central India, and institute a comparison between the cost of production and the sale price of finished iron, or, let us say for the present, of ordinary bar iron.

As the iron works would be erected, for the reasons explained before, as near as possible to the forests, the cost of transport of the ores must first be considered. This would be done in bullock carts, on average good roads, and over a distance of 45 miles. The consumption of a blast furnace in ore and fuel depends on its size.

According to the best experience, a blast furnace does not pay if it is constructed for turning out less than 15 tons of pig iron in 24 hours, and this is also the quantity of pig iron which would fully employ a simple but complete bar iron rolling mill.

A blast furnace, capable of producing 15 tons of pig iron in 24 hours, consumes daily—

		Rs.
1. 23 tons of ore, which would cost as follows :—		
(a) at the place of production, 8 annas per ton	...	11½
(b) carriage to the iron works, Rs. 3 per ton	...	69
2. 22 tons charcoal—		
(a) at the place of production Rs. 2½ ...	...	55
(b) carriage to the blast furnace ...	...	30
3. Limestone; 3 tons @ Rs. 2	...	6
4. Wages	...	28½
5. Management, wear and tear, &c. ...	...	70
Total	...	270

The working of one blast furnace would, therefore, cost per 24 hours Rs. 270, and would produce 14 tons of pig iron at a cost price of Rs. 18 ($\frac{270}{15}$) per ton.

A simple bar iron rolling mill requires daily—

		Rs.
1.	15 tons pig iron, costing	270
2.	4¾ tons charcoal (carriage included)	20
3.	14½ tons wood ditto	22
4.	Wages	108
5.	Management, wear and tear, &c.	120
	Total ...	540

The working of the bar iron rolling mill would, therefore, cost Rs. 540 per day, and produce daily 12 tons of bar iron at the *cost of Rs.* 45 ($\frac{540}{12}$) per ton, or Rs. 1-10 per maund. With the present means of transport, the carriage of bar iron from the ironwork to Agra would be As. 8 per maund, which would, therefore, raise its cost price in that locality to Rs. 2-2 per maund.

Under the present charges of carriage by railway, the cost prices of bar iron per maund, in the principal markets of India, would be as follows:—

	Rs.	As.	P.
Agra	2	2	0
Allábábád	2	8	0
Aligarh	2	3	0
Benáres	2	12	0
Bombay	4	1	0
Káhnpur	2	5	0
Calcutta	3	8	0
Delhi	2	5	0
Jalandar	2	11	0
Láhor	2	4	0
Ludiáná	2	12	0
Lucknow	2	4	0
Mírat	2	6	0
Multan	3	2	0
Ambálá	2	8	0

The sale price would, of course, follow the principles of fair competition. Swedish bar iron, Bowling, Low Moor, and Farnley iron are selling in Agra at about Rs. 7-8 per maund. This price, compared with our cost price, would represent a profit of Rs. 5-6 per maund, which would, however, be diminished as the markets recede from Agra towards Bombay or Calcutta.

Should there be a reluctance on the part of the Indian Government, for fear of seeming to counteract English manufacturing interests, either to lead the way themselves, or to take effective measures to encourage the introduction into India of European iron works, attention is directed to the half

products of iron which might be turned out in India and exported; kinds of iron and steel, which are now largely imported into England from other countries, such as "Spiegeleisen" of which, as mentioned before, large quantities are imported into England. Even America imports "Spiegeleisen" from Europe to the amount of 20,000 tons per annum. This quantity alone would employ four blast furnaces throughout the year, working night and day. The cost of making "Spiegeleisen" is 25 per cent. higher than that of ordinary iron; the cost price would, therefore, be about Rs. 25 per ton; the sale price in England is £6, in America 45 dollars per ton. "Spiegeleisen" being a product of the blast furnace only, the cost of machinery, furnaces, buildings, etc., for the refining process would be saved.

There are other half products of iron which England imports from abroad, such as *acier sauvage*, "glow steel," and raw steel." Of these half products of iron every ounce required by England, America, and other countries, should be supplied by India, owing to its excellent and cheap iron ores, fuel, and low wages.

The Iron Works of Dechauri, in Kumaon.

By Dr. H. Warth.

The Iron Works of Dechauri have been founded near a deposit of ore in the midst of forests at the base of the Himalaya range. The deposit consists of clay iron ore with a moderate amount of iron. The quantity of ore is very considerable. It occurs at the base of hills of Nahan sandstone. The ore is so plentiful that no mining at all is required. The ore is simply dug up and quarried over a surface of above 1 000 feet length along the hillside, and perhaps 300 feet width m'easured down the slope. It is not quite certain whether the deposit is conformable with the overhanging sandstone. The contact is not sufficiently exposed at the place of the outcrop. Very good ore crops out again on the hill in northern extension of the large outcrop, and further on in the river gorge strata which belong, most probably, to the Nahan sandstones, contain small layers of ore, and the deposit appears to thin out there. If this is really the case, however, the deposit of ore at the big outcrop is at least 100 feet thick, and there is no fear as to the ore being easily exhausted. The deposit crops out again at a distance of five miles at Kaladungi, where iron works have also once been erected. The ore at Kaladungi is poor. Amongst the Dechauri ore are different qualities. There are some very good beds, but poorer beds are always associated, where the ore becomes more and more mixed with clay. Owing to the large extent of the outcrop no deep cuttings have as yet been required, so that the succession of beds cannot be

generally followed. Some of the ore is pisolitic, and some ore contains rich nodules. There might be a way of enriching the ore by washing these nodules out of the clay. The following is an analysis of Dechauri ore :—

Peroxide of iron	... ...	54·6
Protoxide of Manganese	... ...	0·3
Alumina	... ...	16·4
Lime	... ...	2·0
Magnesia	... ...	0·5
Silica	... ...	17·9
Potash	... ...	0·2
Phosphoric Acid	... ...	0·6
Titanic Acid	... ...	0·2
Water	... ...	7·1
	Total ...	99·8
	Metallic iron ...	38·3

The Dechauri and Kaladungi ore is different from other ores of the Himalaya. It belongs to a recent tertiary formation; whilst other ores of the Dehra Dun District, Kotkai, Mundi, and Kangra belong to older formations of more or less metamorphosed slates or schists. Further it is a regular brown iron ore, whilst the ores in other localities are non-hydrons hæmatites or magnetic ores.

Ores of the latter kind abound also in Kumaon, and they have been brought into requisition for the Dechauri Works. These ores are found at a place called Khairna, and at Ramgarh, which latter place I visited. Ramgarh is, by a direct road, 23 miles from Dechauri. I went first to Nynee Tal, a distance of 15 miles from Dechauri. The Nahan sandstone strata are met along the road to a considerable height up to the ninth mile. I found in them impressions of fossil wood, and occasionally small nests of coal. Nynee Tal is surrounded by large masses of limestone. From Nynee Tal I proceeded along the Almorah road. After 11 miles is the Dâk Bungalow of Ramgarh. On the road the limestone is succeeded by slates mixed with quartzites and clays, and afterwards more or less metamorphosed slates occur. Beyond Ramgarh Dâk Bungalow the road leads into the Ramgarh gorge, and up the right side of it to the village of Lushgiani. The slates are at many places changed into complete micaceous schists. There is a mine called Pakha mine near Lushgiani, with many surface excavations, and one shaft 100 deep which was inaccessible. Very pure ore was obtained from here. Higher up on the top of the hill is the Gualakuri mine, 6 miles from the Ramgarh Bungalow, and 32 miles from Dechauri by the Nynee Tal road. It is an open outcrop worked like a quarry 100 feet long. The ore is about

20 feet thick, forming a seam of siliceous hæmatite (not a lode) with about half pure ore and half impure ore, and quartzite. From here a great quantity of hæmatite had lately been taken for Dechauri. About the seam is a stratum with a purple powder, probably containing manganese. The top layers are soft white mica schist. One hundred feet depth in the direction of the seam, which slopes towards the interior of the hill, and 100 feet width would represent above 300,000 maunds, which is enough for two years' consumption of the Dechauri blast furnace, (Dechauri blast furnace produced pig iron at the rate of 50,000 maunds per annum). Gualakuri being only one of a number of outcrops, it is evident that the amount of ore in the neighbourhood is quite up to the supply of iron works on a large scale. The configuration of the ground is such that the extension of the Gualakuri seam might just pass through the Pakhakhan mines. It is probable that the two deposits are identical, notwithstanding the change in the appearance of the ores. The following are analyses of some ores. The figures for Gualakuri are the average of three analyses. The ore mentioned as Lushgiani cannot be from another but the Pakhakhan mine. Natwakhan is a mine low down in the valley, which I did not visit.

	Gualakuri.	Lushgiani.	Natwakhan.
Peroxide of iron	45·6	70·3	81·2
Protoxide of iron	9·3	12·0	...
Protoxide of Manganese ...	...	0·3	8·1
Peroxide of Manganese ...	0·7	...	...
Oxide of Alumina ...	4·2	3·9	3·4
Magnesia	0·5	3·2	0·5
Silica	38·2	8·2	4·2
Phosphoric Acid	0·1	0·1	0·1
Sulphur	...	...	0·1
Water	1·9	2·3	2·2
Total ...	100·5	100·3	99·8
Metallic iron ...	39·4	58·6	56·8

The Ramgarh ores, with the exception of Natwakhan, contain some protoxide of iron in addition to the peroxide. They are consequently more or less magnetic. Specimens of the ores influence a magnetic needle. Different sides of the same piece act in opposite ways on the magnetic poles. In no specimen did I find the magnetism so strong that the specimen would attract light iron filings. I found some very pure and highly magnetic ore similar to Gualakuri ore near the 9th mile on the road from Dechauri to Nynee Tal. On both sides of the road pieces were lying about amongst debris of Nahan sandstone. They were much rounded at the corners, and generally worn at the surface. The rocks to the north were limestone, but the hill on the south side of the road might contain older strata underneath the debris, so that there is a faint chance that the pieces I found may have come from a deposit close by

instead of having been brought there by smelters. It is almost incredible what number of blast furnaces have been erected for the smelting of these ores. At Kaladungi, where the Nynee Tal road from Moradabad begins to ascend, no less than four blast furnaces have been erected. In these it was intended to smelt the Kaladungi ores with charcoal obtained from the forests at the base of the hills. Only two of these furnaces have ever been worked, and all are at a standstill now. At Dechauri, Mr. Campbell, Superintendent, Rurki, showed me the old blast furnace with which he began making pig iron in 1857. His furnace was afterwards replaced by the larger one which has been at work up to lately. Besides this large works were begun at Dechauri by a company, consisting of two blast furnaces, a building for converting the pig iron and a building for rolling mills. The whole came to a standstill for want of funds. On the road to Nynee Tal from Kaladungi, within only about five miles from the hill station near the Kurpa Tal (lake), are two blast furnaces with all their requirements now abandoned. Situated between Kaladungi and Ramgarh these had had the choice between the ores of both places, and for fuel they depended on the forests of the higher mountain regions. Lastly, in the valley at Ramgarh, there is the complete outer masonry of a blast furnace with the walls of houses now all overgrown with thickets. Thus there are no less than eleven blast furnaces to be counted in various stages of completion or of ruin, and of all these only one has been working of late, and even this one is at the moment standing still. With so many works failing from their commencement the conversion of the pig iron into wrought iron has been little attended to, and not at all practised of late.

I was very much pleased with a small hammer work at Ramgarh. Mr. Franken, the Engineer in charge of Dechauri, told me that in this the raw blooms made by the native process have been worked up into fit shape for commerce. It was the very thing which I proposed for Kangra in my report of 1874, (printed in the *Punjab Government Gazette*). An overshot waterwheel worked a blowing machine, consisting of two square wooden boxes with pistons, valves, &c. The blast was led to two hearths on which the blooms were heated with charcoal. Then there was a second waterwheel on a large horizontal beam. This beam had two rings and thumbs, which lifted two hammers of about six feet length each. This must have worked very well. There was also a Cupola furnace of 12 feet height. I would have thought that this was used for smelting the ore by the native process into blooms, but I was told that it only served for some experiments as to the quantity of iron yielded by the ores.

The blast furnace at Dechauri is 39 feet high, and has a diameter of 5 feet 3 inches at the stop, 10 feet at the widest part, and

3 feet 6 inches at the hearth. It is built of local sandstone, and lined below with small bricks made of a sandy fire proof clay, which is found embedded above the iron ore. The furnace is in every respect well fitted out. A canal brings water on an overshot wheel which drives a pair of horizontal cast iron blowing cylinders, and a couple of water pumps. These pumps supply the lift which works from a reservoir on the top of the lift tower. The pumps also supply water for the cast iron watertugers, &c. The blast was heated in cast tubes of oval section, the heat being created by burning furnace gases only. The heat of the blast was very great, rising to 1,200 degrees Fahrenheit. Zinc has repeatedly been melted by the hot air. The furnace is closed at the top with a cone apparatus. The outturn, Mr. Franken told me, was at the rate of 50,000 maunds a year. The fuel was charcoal from the surrounding forest, and tufa limestone was used as flux.

The reason why the Ramgarh ores were used in addition to the Dechauri ores was not only their superiority, but the facility with which the process was carried on when the two ores were mixed. The Dechauri ore contains almost as much alumina as silica, and the addition of purely siliceous ores with limestone as flux must have proved an advantage. Only the Dechauri iron ore costs almost nothing, whilst the ores from Ramgarh cost very much in transport. The digging of the ores at Gualakuri cost less than one anna a maund, but bringing the ores down the mountain side on men's heads, costs two half annas per maund. Then from the Ramgarh depot the ore was once brought for eight annas a maund to Dechauri, but contractors not being available, the officer in charge had actually to purchase cattle, and take the transport of the ore into his own hands. The transport in the mountains is very difficult. Outside the mountains it becomes at once cheaper, thus the pig iron costs only five annas a maund to bring from Dechauri to the railway station of Moradabad, about fifty miles off. The production and transport of charcoal was not excessively dear, the only complaint being the exhaustion of a great portion of forest, and the deficient reproduction owing to deliberate grazing.

The following is an analysis of two kinds of slag from Dechauri :—

Slag.	Brown cinder.	Dark & glassy fracture.
Silica	38·0	40·6
Alumina	10·5	17·0
Lime	20·6	23·6
Magnesia	1·6	1·9
Protoxide of iron ...	8·4	1·8
Protoxide of Manganese ...	9·0	12·1
Total ...	88·1	97·0

In the first case the large percentage of iron in the slag shows that the furnace was not working normally. The second slag from normal working shows by its proportion of alumina that a large admixture of Ramgarh ore had taken place. More than one-half must have been Ramgarh ore. Most of the product is grey iron numbered from 1 to 3, but I was also given some samples of white and of mottled pigs which formed part of 20,000 maunds altogether in store.

The following is an analysis of grey Dechauri pig iron No. 2:—

Iron ...	...	...	...	92·2	91·9
Carbon	...	...	...	4·0	3·9
Silica	...	...	...	1·7	1·6
Sulphur	...	...	...	nil.	nil.
Phosphorus	...	...	...	0·7	0·9
Manganese	...	...	...	1·2	1·3
		Total	...	99·8	99·6

As already mentioned the work at Dechauri is at present standing still. Mr. Ness, Government Mining Engineer, Warora Colliery, was at Dechauri to report to Government on the future prospects of the works. His report, which will no doubt be obtainable after some time from the Government, North-West Provinces, will contain detailed information about the economy of the works.

From his report it will be seen why it is so difficult to render in these parts the iron manufacture on a larger scale remunerative. Besides the costly transport of ores, charcoal, and pig iron there appears to be a difficulty regarding the skilled workman. I found two European workmen at Dechauri who were about to leave, and there is no chance of the furnace work being continued by native workmen only.

I had the pleasure of witnessing some experiments which Mr. Ness made in reducing iron ore to metallic sponge. Not only the pure Ramgarh ores, but also the Dechauri ore, gave perfect metallic sponge on being heated in a crucible with charcoal powder.

It is desirable to manage the manufacture of iron in this country in such a way as to suit the capabilities of the local workmen. The work at the large blast furnaces seems beyond them, and Mr. Ness is endeavouring to introduce a simpler mode of working. It does not appear to me that he looks to the direct manufacture of wrought iron for this end, but it seems he would rather melt sponge down in charcoal furnaces with blast, and produce pig iron. By making the sponge first he would do away with the whole of the reduction process which is now occupying half the pace of the blast furnaces.

This way he will not only save much in the size of the blast furnaces, but by applying perfectly metallic sponge he will do away with the whole series of difficulties which arise at blast furnaces out of irregular reduction of the ore.

The native direct process of smelting is only applicable to purer ores, and even with them is always accompanied by a great waste of iron. Even where this waste can be afforded the process requires also so much fuel and labour that it competes rarely with imported English iron. With the greatest ingenuity it will not be possible to improve substantially the native process by mere changing of the manipulation and size or form of the apparatus.

The use of sponge in the direct process is known elsewhere, and wherever the native process should have to be practised, it would be well to take a hint from Mr. Ness and to reduce the iron ore before bringing it into the native smelting furnace. The process will be more regular, and where circumstances are favourable a saving may be effected.

Until some other invention is made it is indispensable for any improved system that pig iron be manufactured. The blast furnaces should be reduced to such a size that their working will be within the capabilities of native workmen, assuming that they are guided by an officer who has a theoretical and practical knowledge of iron making.

The size of a blast furnace may be reduced almost to any extent on application of the following measures :—The ore will all be roasted, or where it can cheaply be done Mr. Ness's proposals may be adopted, and the iron ore used in reduced form; further the limestone used as flux will all be previously burned; further the blast will be heated ; lastly, some allowance will be made for the smaller size of the furnace by greater expenditure of fuel. By a combination of these measures the size of a furnace may be reduced, so that there will be no reason why clever native workmen should not manage it under competent supervision.

The question remains then how the pig iron is to be made into wrought iron. To think of the Bessemer process is of course out of the question in this country.

The great discovery made by Messrs. Thomas and Gilchrist in 1879 is not destined to prove of advantage for Indian iron making.

On the contrary as Thomas and Gilchrist's invention makes it possible to Bessemer the pig iron obtained from inferior ores, the production of good wrought iron must in future become cheaper in Europe. Therefore, we must also expect that better wrought iron than heretofore will be sold in India at ordinary prices, and that the Indian iron will lose the claim of the superior quality.

Apart from the Bessemer and the Siemens-Martin process, which is also too elaborate, there remain only the puddling and the hearth-refining process, and of these we have to choose the latter. The hearth-refining process is not at all inferior to the puddling process. The chemical reactions are almost identical,

and it is only the difference in the fuel which decides for either of the methods. For charcoal the hearth-refining process is the one to be adopted. The amount of material worked at a time, *viz.*, the size of the blooms, can be reduced at will, and the work can be so carried on that the native workman will do it without any difficulty.

The consumption of pig iron and charcoal by this process are not excessive, and some saving of fuel can be effected by the application of hot blast. With a properly designed hearth the work can be done quite mechanically. The pig iron is smelted between the charcoal, and as it trickles to the bottom is acted upon by the blast, which oxydises through the medium of oxide of iron, the silicon, carbon, and phosphor. After the first smelting down, the partially refined metal, which has solidified at the bottom of the hearth, is brought again to the top of the charcoal fire, and again smelted down. Either this second or a third smelting suffices to produce a bloom of pure wrought iron, which only requires hammering out. This way of making wrought iron is very much to be recommended for Indian charcoal works, and it may be that preparations for this very process at and near Dechauri are only wanting, because the iron works did not mostly attain beyond the first stage of pig iron making.

On the production of Lac in Hoshiarpur District.

By W. Coldstream, C.S., *Deputy Commissioner.*

The district of Hoshiarpur lies between the Beas and Sutlej Rivers. Its surface is, roughly speaking, half plain and half occupied by the outlying ranges of the Lower Himalayas, corresponding to the Sivalik ranges east of the Sutlej. It may therefore be called a submontane district. Lac is produced in all parts of it, at least in the plains and in the valleys between the hills. It is more abundant in the latter.

It affects chiefly the Beri (*Zizyphus Jujuba*), and Kikar (*Acacia arabica*); but is also found on the following trees :—

Pipal	...	(*Ficus religiosa.*)		
Sirīn	...	(*Acacia Sirissa.*)		
Barh	...	(*Ficus indica*)	...	Banyan.
Pilkhan	...	(*Ficus venosa.*)		
Lasura	...	(*Cordia Myxa.*)		
Anjir	...	(*Ficus Carica.*)		
Dhāk	...	(*Butea frondosa.*)		
Phagūra	...	(*Ficus caricoides.*)		
Patājan	...			
Gular	...	(*Ficus Cunia.*)		

Thus it is found on six species of Ficus.

The lac produced by the various trees differs in quality. The Lac produced on the Zizyphus is deemed the best, and next to it comes that produced on Sirris, Kikar and Pipal.

There are two seasons for production—February to April, and July or August. The crops are collected in June, and October or November. The same tree is said not to produce two crops in the same year. The autumn or October crop is considered the more valuable of the two.

The artificial propagation of lac is understood by very few persons, but seems to be occasionally practised. The method adopted is to tie a small branch with the insects on it on the tree which it is desired to affect. The writer has found it very easy to propagate lac on Beri trees in this manner. The twigs containing cells of the insect were tied on to the trees in July; shortly after the new swarm appeared and spread over the nearest branches of the tree. There appears, however, to be among the people a great dread of the tree being injuriously affected by the spread of lac upon it, and this is probably the reason why propagation is not carried on to a greater extent. In cutting lac off a tree a few twigs containing cells are allowed to remain to furnish a crop for next year.

There existed a deep and widespread prejudice among Hindus against having anything to do with lac. This was particularly strong among the Bhabras (called in other districts Saraogis.) Lac was considered a kind of disease or leprosy of the tree, and to be an unclean substance. Its red color and its animal origin are sufficient to account for this prejudice. It has disappeared, to a great extent, within the last ten years, owing to the great value which lac acquired in the market. There have been, of recent years, many disputes in the Civil Courts as to the relative rights of landlords and occupancy tenants to take the lac from trees growing in an estate. The question was not discussed at the time of the Revenue Settlement of the District in 1852, lac having then but a small marketable value.

The crop of lac on roadside trees is sometimes sold by Government to a contractor, who is allowed to cut off twigs and branches of a certain thickness. In 1876 the lac on the roadside trees in Unah pergunnah was sold for more than Rs. 400. The crop, however, varies much in quantity from year to year, as does also the value of lac in the market.

Tea at the Andamans.

Our readers may recollect noticing some time back the mention in these columns of the fact that tea planting was being tried at the Andamans. During the recent Poojah holidays we took the opportunity of a sea trip to Port Blair to pay a visit to "Aberdeen,"—the island of the Andaman group, upon which tea-growing has been commenced; and where also other growths are being experimented with. The land is slightly undulating, and rises only some 200 feet from the sea level. The soil is good loamy clay with sandstone, and the subsoil is of a character to afford excellent drainage. The general lay of the land, also, is favorable to natural surface drainage. The bushes, which are mostly Assam (rather mixed) hybrids, are planted about 5 ft. × 4 ft. 6 in.; and at present are nigh four years old. They are of good height, and now require to spread. The general appearance is of the healthiest character; the wood is clean, and the leaves are as fresh and glossy as could be desired, while there is now a flush on which would make many a hill planter's mouth water; and there is an entire absence of blight of any kind.

The land is kept thoroughly well hoed, the earth is packed well up round the roots of the bushes, and the whole plot of land, where the tea is growing, is as clean as the beds on a well-cultivated flower garden; and yet from what we gathered, the labour force up to date has been small; but then it has been well directed and controlled. Unfortunately, the flush, which we have referred to as being now on the bushes, will be lost, because the factory is not yet complete. It seems strange that the P. W. Department should have allowed such a thing to happen, for, as we understood on the spot, it was not for want of due representation of the necessity for the earlier erection of the factory that the delay has occurred. However, a few months will see a very serviceable building completed, and it would be well if the authorities were at once to arrange for a competent tea maker to take charge, and give the experiment a fair chance; for it is no use growing good leaf if it is to be spoilt in the manufacture; and, although the extent of land at present under cultivation is small, an assistant would find ample occupation in clearing, cultivating, and extending, in addition to his supervision of the factory. The officer in charge at present is Lieutenant-Colonel Berkeley, who, himself possessing a tea plantation in the Nilgiris, is, besides, a good botanist and an experienced planter; but his duties at Port Blair, as Chief Commissariat Officer, are so multifarious and onerous, that, although he takes the warmest personal interest in this experimental tea garden, which does him so much credit, and although he has been thoroughly successful in its development, yet he cannot neces-

sarily devote that regular and close supervision which is necessary,—more especially so now that the bushes are arriving at maturity, and that constant manufacture will soon be required; for after March next, when the dry weather ceases, the flushes may be looked for in plenty, the climate giving for 8 months of the year that moist warmth which the tea plant luxuriates in and thrives so well under. In fact the climate may be compared to that of favorably situated Indian terai land, with this difference, of course, that there is always more or less of refreshing breeze from the sea; and, as the places where cultivation has been begun in earnest have been well cleared of trees and jungle, there is little or no fever.

It would, we think, be a matter for much regret if the Government should allow an experiment thus auspiciously commenced to fail of practical good for want of due continuous professional supervision; and we trust to hear soon that it has been resolved to provide Lieutenant-Colonel Berkeley with a competent assistant, able to carry out his orders, and to see to the minutiæ of the factory and the garden. There are only too many planters just now out of employment, whose services could be secured at a very moderate salary; for living at the Andamans is cheap, and it is almost impossible to spend much money there,—all supplies being furnished through the Commissariat. As to isolation, in this respect a man would be not so badly off as in many parts of Assam. There are several European Superintendent employees on the Island, besides of course the settlement officials; and, as each departmental head appears to be provided with a boat and convict crew which remains at his command, it is a matter of only an hour or less to communicate with the different islands of the Settlement. (*En passant*, we may mention that anything more charming than a row or a sail on the clear blue sea inlets among the group of islands can hardly be imagined.)

In speaking of tea cultivation at the Andamans the question not unnaturally arises whether it is a desirable thing for Government to step in as cultivators to the possible injury of private enterprise elsewhere,—it being notorious that the supply of Indian tea is already greatly in excess of the demand. Well, on this point we can only say that, if we thought there was any intention of carrying the matter beyond the phase of a sufficiently large experiment with a view to demonstrate the practicability of successfully cultivating tea on the island, we should be the first to condemn it; but, as we take it, if ever cultivation on any large scale be attempted, the whole affair will be made over to private hands. At present there seems to be considerable objection on the part of Government to permitting the advent of free settlers, or non-official capitalists from outside. One reason for this is, perhaps, that as all the labour on the Settlement has to be performed by

convicts, and as the number of these (though amounting to some 12,000) is not sufficient for present requirements, it would be impracticable to afford colonists the necessary assistance of labour or protection of life. And if, again, coolies were brought from India, in any quantity, the civil administration would have to be strengthened. No doubt it will follow, as a larger number of ticket-of-leave men are accumulated on the islands, that many of the present disabilities surrounding free immigration will be removed; and we fully believe that a few years hence the population will be largely increased from within. Convicts, who have served ten years with good conduct, are allowed to marry, and numbers now are scattered about the Settlement as free labourers on their own account; and it appears that they are as a rule thoroughly well behaved, and *so well off that few wish to return to their native land even* had they the chance.

The Government, besides experimenting with tea, has tried coffee, but the climate seems unfavorable to the plant, as just at the time of year when rain is most wanted for coffee, there is least rain at the Andamans. Sugarcane, however, bids fair to be a great success, and cocoanut planting has proved highly profitable. In fact, almost anything will grow well there, and the grass is so luxuriant that hay to almost any extent might be manufactured. All these things of course would pay better if there were a sufficient local demand to absorb the yield of various kinds which the islands are capable of affording; and that is why we venture to express the opinion that Government would do wisely, as soon as it feels it can safely do so, to encourage settlement from outside. There are many men in India on pensions which permit them only close economy here, who would be able to live at the Andamans far more comfortably, could they take a small quantity of imported labour with them. Thus, cultivation would increase, farms would spring up, additional land would gradually be *cleared, and a free population would in time accrue, affording* protection rather than the reverse to the settlement.—*Indian Tea Gazette.*

Report on the Forests of Mauritius.

By R. Thompson, *Deputy Conservator of Forests.*

Part 1.—General.

Geographical position and area.

The Island of Mauritius lies in the Indian Ocean between the parallels of South Latitude 19° 58′ and 20° 31′; and East Longitude 57° 17′ and 57° 46′; and occupies an area of some 705 square miles. In shape it is an irregular oval, with the broad end resting towards the south. Its greatest length from *Cap Malheureux* to *Pointe d' Esny*, north and south, is 39 miles; and its widest part across, from east to west, 34 miles.

Districts.

2. For administrative and general purposes it is divided into nine districts as follows:—

	Area in square miles.
1. *Port Louis*	... 10·0
2. *Pamplemousses*	... 87·0
3. *Rivière du Rempart*... ...	... 58·0
4. *Flacq*	... 113·0
5. *Grand Port*	... 112·0
6. *Savanne*	... 92·0
7. *Plaines Wilhems*	... 70·0
8. *Moka*	... 68·0
9. *Black River*	... 95·0
Total	... 705·0

These districts are situated as follows:—

Rivière du Rempart and *Pamplemousses*, extending from coast to coast in the north; *Port Louis* on the west coast, south of *Pamplemousses*; *Flacq* on the east coast, south of *Rivière du Rempart*; *Moka* and *Plaines Wilhems*, the former lying wholly, and the latter almost wholly in the interior; *Black River* on the west coast, west of *Plaines Wilhems*; *Grand Port* on the east and south-east coasts; and *Savanne* on the south coast.

Statistics, population, &c.

3. The total population of the Island in 1879 was 357,000 inhabitants, of which number the Indian population was 243,000, or very nearly two-thirds of the total. The average density per square mile of surface is therefore over 507 souls. The revenue of the Colony in the year 1878 was Rs. 78,95,536, and the expenditure Rs. 73,45,786, showing a surplus of revenue over expenditure of Rs 5,49,750.

The export in the same year of sugar, the chief article of colonial industry, was to the extent of 130,732 tons, and which was valued at Rs 3,36,17,848.

In the same year there were 122,000 acres of land under sugarcane cultivation, which amounted to just something more than *one-fourth* of the total area of the Island, which has been estimated at 451,200 acres. Taking it by districts, the following table shows the percentages under cane in each :—

	Area of District in acres.		Area in acres under Canes.	Percentage under Canes.
1. Port Louis ...	6,400	acres	...	...
2. Pamplemousses ...	55,680	"	8,650	15·0
3. Rivière du Rempart	37,120	"	12,250	32·4
4. Flacq ...	72,320	"	28,435	40·4
5. Grand Port ...	71,680	"	24,333	33·3
6. Savanne ...	58,880	"	18,845	32·2
7. Plaines Wilhems ...	44,800	"	13,350	29·7
8. Moka ...	43,520	"	11,175	25·5
9. Black River ...	60,800	"	4,950	8·0
Total ...	451,200		121,988	mean 27 p. cent.

In addition to sugar other principal exports from the Island are vanilla, aloe (*Fourcroya gigantea*), fibre, molasses and rum.

Topographical features.

4. The following general description by Dr. Meldrum, Director of the Royal Alfred Observatory, is extracted and reproduced here by kind permission, from a paper read by him before the British Meteorological Society in June 1868. It is an accurate and complete general description of the Island :—

"The principal feature in the conformation of the Island is, that it consists of a central table land, which is separated from the plains on and near the coast, in some places by lofty mountain chains, in others by steep precipices, and in others by more gradual, but still rapid, descents. This table land comprises the whole of Moka and nearly the whole of Plaines Wilhems, together with the more inland parts of Flacq, Grand Port, Savanne and Black River. Its central ridge, *which is the principal watershed of the Island*, extends in an east by north direction, from the Savanne mountains in the south to the northern limits of Moka, over a distance of about twenty miles, and, like the table land itself, is most elevated in its southern half." (The table land in the extreme south has an elevation of 2,300 feet).

"From this ridge the ground slopes on either side forming here and there, at heights of 700 to 1,400 feet above the sea level, extensive and almost level plains, which, in some places, are abruptly separated from the littoral plains, several hundreds of feet below them, by almost perpendicular cliffs. The more gradual ascent in these intervals between the mountains commences at short distances from the sea, and continues up to heights of 1,200 to 1,800 feet, from which there is a similar

descent to the opposite coast. The railway from Port Louis (the capital of the Island) on the west, to Mahebourg, on the east coast, crosses the table land in a south-east and north-west direction; and the height of the stations determined by levelling, show the ascent and descent in that part of the Island. Thus, at four miles from Port Louis, the elevation is 392 feet, at eight miles 923 feet, at eleven miles 1,311 feet, and at sixteen miles, or about half way, 1,822 feet; the line then descends to 1,000 feet at twelve miles, 559 feet at seven miles, and 258 feet at five miles from Mahebourg. Generally, however, the table land is separated from the littoral plains, or the sea, by mountains of which there are three groups, *viz*:—

"(1). The Port Louis group in the north-west, the central line of which runs about twelve miles in an east by north direction, at four to eight miles from the sea." (Towards the north and west it throws out several spurs, with valleys opening towards the sea,—betweeen two such spurs, in the south of the range, lies Port Louis the capital.) "The height of the range varies from 1,000 to 2,600 feet."

"(2). The Black River and Savanne group, consisting of a series of mountains and elevated ridges from 1,000 to 2,700 feet above the sea level." (They extend from Mount Rempart in the north-west to Mount Savanne in the south-east, a distance of over 14 miles. These mountains form the sea-ward scarp of the elevated table lands in the south-west corner of the Island. Viewed from the north, they present the appearance of high, well-wooded ridges, sloping away from west to east, and isolated wooded hills; but, as seen from the south, they present a bold and striking scarp, throwing out several irregular spurs, and valleys opening down to the sea. Everywhere the slope of this range on this side is steep with large surfaces of exposed rock.)

"(3). The Grand Port and Flacq group, in the south-east and east, rising to the height of 1,200 to 2,100 feet, and consisting of three main chains running nearly parallel to one another in a westerly direction, the principal chain being about fourteen miles long."

"Most of the main chains send off branches, which form a succession of valleys and gorges opening towards the sea. The upper portions of the mountains and elevated ridges are generally composed of bare rock, presenting here and there the appearance of lofty cones, peaks, turrets and serrated ramparts." (Several craters, still in good preservation, of extinct volcanoes, are to be met with on the Island, such as the *Trou aux Cerfs*, the *Grand Trou North*, and *Grand Trou South*; besides various others.)

"Between the bases of the mountains and the sea there are more or less all round the Island, low-lying and nearly level plains.

"Rivière du Rempart and Pamplemousses, north of the Port Louis mountains and portions of Flacq, are comparatively one extensive plain, the greatest elevation attained by the railway, which passes through them, being only 329 feet at a distance of six miles from the sea.

"The Island is drained by a great many rivers and streams, the largest of which take their rise on the table land, receiving in their courses numerous tributaries from the mountains, and, as they flow onward through deep-wooded ravines, forming in some places, picturesque waterfalls. They all vary in volume according to the season, and occasionally some of them become quite dry.

"Both in the interior and near the coast there are lakes, marshes and swamps. The principal of these are the *Grand-Bassin* in Savanne, at an elevation of 2,000 feet, and covering a superficies of from thirty to forty acres; the *Mare aux Vacoas* on the confines of Plaines Wilhems and Black River, about 1,900 feet above sea level, and having an area of about 200 acres; the *Mare aux Lubines* and others on the lowlands of Flacq; a number of marshes in the lower parts of Grand Port; and several ponds, swamps and marshes near the sea in Black River, and in the neighbourhood of Port Louis."

Principal rivers.

5. The principal rivers, and which rise from the table land, are the *Grand River South East*, having a course of 18 miles, *Grand River North-West*, a course of 14 miles, *Rivière du Rempart*, the *Tamarind River*, *Black River*, *Rivière du Poste*, besides numerous smaller streams. The two grand rivers, above mentioned, drain, through their affluents, the whole of the central parts of the table land; these affluents rise in the Median ridge between *Butte Chaumon* and the *Ripailles Estate* in the north, and within which tract is comprised the most important catchment area in the whole Island.

Roads and railways.

6. There are upwards of 350 miles of main public, and about 8 miles of district roads, kept up in a high state of efficiency. The roads are all laid down with *macadam*, which is maintained in good repair.

In addition there are endless private roads, maintained by proprietors of sugar estates, all over the Island. There are besides 86½ miles of made railways in excellent working order, *viz.*, (1), North line, 31 miles, which leaves Port Louis and traverses the districts of Port Louis, Rivière du Rempart, Pamplemousses and Flacq, ending at Grand River south east; (2), Midland line, 35½ miles, which, starting from Port Louis, ascends the plateaux, and traverses the whole length of the districts of Plaines Wilhems and Grand Port, ending at Mahebourg on the east coast; (3), Savanne Branch, 11 miles. This branch leaves the Midland line at Rose Belle, in the Grand Port Dis-

trict, and proceeds in a southerly direction to Souillac on the south coast; and (4), Moka Branch, 9½ miles *finished,* leaves Midland line at Rose Hill, in the Plaines Wilhems District, and traverses the whole length of Moka. It will ultimately be carried on to *Trois Ilots,* a further distance of 4 miles. It will thus appear that no less than eight out of the nine districts into which the Island has been divided, are provided with railways traversing their entire lengths, and which are carried along well chosen lines. As regards roads and railways, the Island is covered with them as with a net-work.

Geology.

7. For purposes of this report, it is not necessary to enter into any minute description of the geology of Mauritius; what will suffice being a brief and rapid general sketch of it.

The Island is essentially volcanic, though what appear to be metamorphic rocks, occur as an older formation, in at least two places which are known to the writer. The first of these sedimentary beds occurs in the form of a small conical hill, projecting, as it were, out of and rising above the igneous mass, known as the *Rivière Noire* mountain, and is to be found at a spot which is half way up the side of this range, where the road from *Case Noyale* crosses it on the way to *Chamarel* Estate. From the plain below these beds can be recognized by the forest vegetation on them, which differs, not only in actual growth, but also in the species of which it is composed, and therefore has a distinct aspect distinguishing it from the surrounding vegetation.

The second instance of the occurrence of altered sedimentary beds is near the *Midlands* estate, in the centre of the Island; the place is known as *Mount-La-Selle.* The beds are crystalline chloritic schists, and have undergone considerable uplifting and contortion. They dip away to the south and appear to have a strike west by north-easterly.

On the south scarp there are found considerable quantities of coral and beach sand, above the line, separating the doleritic lavas which spread out below.

Dolerite principal rock.

8. Doleritic lavas form the chief mass of the Island however, and present considerable horizontality on the manner in which they have been laid out immediately around, and sometimes considerably beyond, the volcanic foci which gave them birth.

In consequence of this tendency to horizontality, terraced and undulating plains have been produced, and which rise one above the other to the highest levels of the Island, one of these plains being at an elevation of 2,300 feet above sea level. The lower beds of these lavas are of great thickness, and are, apparently, equally horizontal with the upper beds, which are however of less thickness. Considerable scarps occur, due to denudation, at a short distance from the sea all round the Island,

and over which the rivers, rising in the interior, precipitate themselves, forming beautiful waterfalls and grand cascades—notably those of Chamarel and the Tamarind river. The mountain peaks and precipices, which are exposed to view, likewise exhibit in a marked manner a horizontal arrangement of the different lava overflows; these beds being defined by thin bands of ash and scoriæ interstratified with them. The mountains in the Black River district, however, exhibit only the lower members of these irruptive rocks, *viz.*, the *diorites* which form the axes of the range, the upper and more perishable *dolerites* having all disappeared under the action of sub-aërial denudation. It is not at all improbable that diorite, as being the lower rock, composes the mass of all the mountain chains of the Island. It would also appear that the volcanic action has long since ceased in those quarters, though considerable activity, during more recent times, has gone on in the middle of the Island; proofs of which are not wanting, since several extinct volcanoes have their craters still in good preservation. These later and successive overflows have raised the centre of the Island to its present form, and given to it its present elevation. The masses of lavas, which have laid down the terraces and formed the upland rolling plains, were evidently ejected through a chain of vents which occupy what is now the medial ridge of the Island, commencing in the south-east, and extending across, in a north-easterly direction, for a distance of 20 miles to the *Callebasses* mountains. These recent overflows would appear to have occurred in times when parts of the Island were covered with some sort of vegetation, for we find in some of the slags and scoriæ picked up, the charred remains of vegetable tissues in a sufficiently good state of preservation to leave no doubt of their identity. The existence of caverns and underground channels, into which small rivers frequently disappear and are not seen again, may also be pointed out.

Secondary minerals.

9. As secondary minerals, associated with the Mauritian dolerites, may be noticed a very abundant *glassy* felspar, (probably *orthoclase*) so abundant that the rocks in which it occurs are prophyritic. *Pyroxene* also occurs in some of the ash beds, crystallized in acicular masses. *Calcite* has been found occurring, though rarely, as veins in the dioretic masses of the Black River mountains. *Magnetite* is a constituent of most of the later dolerites, and is abundant in the rocks near and around extinct craters, its presence there being detected by the behaviour of the magnetic needle.

Interstratified with the lavas occur bands of red and brown coloured *bole*, and which is present throughout the whole series. In various parts, especially above Port Louis and Petite Riviére these bands of *bole* are of considerable thickness. *Scoriæ* and *lapilli*, sometimes combined with *bole*, cover, as with a

crust, tracts of considerable extent in the higher levels of the Island.

The form, known as the columner structure, occurs in these dolerites in some of the mountain ranges. A field of considerable extent of this structure may be seen on a part of the bambou range overlooking "*Trois Ilots.*" Exfoliating concretionary forms are abundant wherever the rock masses are undergoing decomposition, notably in the lower parts of the Island, and also along some parts of the coast. Frequently *lapilli* in combination with *bole* occurs as a surface soil, such as may be seen in parts of Petite Riviére and du Rempart; such soils are dry and unfit for cultivation, except under irrigation: and frequently the hard spheroidal *cores* of concentric nodules are very abundant, such as one would expect to meet with in the trap fields of Western and Central India.

Diorite.

10. *Diorite, which composes the chief mass of the* Black River mountains, has imparted a peculiar physiognomy to that district. Since the rock is black (owing to a dark colored horneblende) the exposed surfaces everywhere present a peculiar sombre hue; even the boulders strewn in the beds of the torrents, which come out of those mountains, are black; as likewise are the gravels and other detritus occurring in the valleys.

Soils.

11. In the decomposition of the dolerites there has resulted an extremely fertile soil. This soil is either red or brown in color, and is only in some parts of the Island of any considerable depth. However, as a rule, it is extremely shallow, and where only recently reclaimed from forests, carries a layer of *humus* of from two to six inches in depth. The presence of this *humus* makes the soil extremely fertile, and it is thus especially suited for the cultivation of the sugarcane. In the older reclaimed soils no trace of this *humus* now remains. It is well known that direct exposure to the sun's rays and to the dry heat of the air in summer causes the *humus* to decompose and to become dry and powdery, and *in that state it is easily carried off and scattered abroad by the winds.* Hence under a want of proper treatment, even a rich virgin soil, without it, unless kept shaded, quickly deteriorates, and is eventually lost to the sugar planter, who, on finding that the soil can no longer grow his canes, abandons it for land which may still be under forest.

The whole of the Savanne district, the greater part of Grand Port and Flacq, Moka and Plaines Wilhems, are covered, more or less, by the red clayey soil alluded to above. The red tinge is derived by it from the hydrated oxide of iron formed during the weathering and decomposition of the doleritic rocks—the felspar, which these rocks contain in such abundance, being essentially a silicate of alumina and potash.

In the littoral, here and there, may be met patches of true black soil, containing a large quantity of organic matter; it is of highly hygroscopic quality, and parts but slowly with its moisture. During prolonged dry weather, however, large cracks appear in it. In India the black soil is considered extremely fertile. A form of decomposition of the doleritic rocks has been observed, being the disintegration of them into very fine gravel of a grey or greyish blue color. Such soils, when formed, are mechanically pervious to moisture, just in the same way that sand is, and like it forms a loose mass which readily parts with any moisture it may have received to evaporative agency.

These soils have no hygroscopicity, are always dry, and are of little value for short-rooted crops, except under irrigation.

They commonly occur in the lower parts of the Island.

Meteorology. Seasons.

12. The climate of Mauritius is tolerably equable, although it is capable of being divided into a warm and a cool season, neither of which is necessarily dry in the sense the want of rainfall would imply. It rarely happens that no rain falls during any month. The warmest months are the rainiest; but a considerable quantity of rain likewise falls during the cooler months; more especially is this the case in the higher parts of the Island directly exposed to the south-east trade wind.

The warm weather is said to last from November to April, January and February being usually the warmest months. The cool season lasts from May to October, June, July, and August being the coolest periods of the year. The seasons, as regards rainfall, are divided into the rainy and the comparatively dry. Since two-thirds of the annual rainfall are received between the months of December and April, these in consequence are considered the rainy months, although, as said before, there is no period of the year when it does not rain.

Situated in the midst of a wide ocean, and lying within two degrees of the Tropics, Mauritius may, comparatively, be said to be ever bathed in an atmosphere of vapour. Its small area, and that fairly well covered with vegetation, even at the present day, cannot be said to exercise any great influence in causing the moisture-bearing winds that blow over it from becoming drier; except in the sense that they part with some of their moisture in frequent showers of rain in their passage across the Island, and to effect which they are forced to rise to elevations of 1,800 to 2,000 feet above sea level.

The tables of relative humidity of the atmosphere, recorded in the Royal Observatory of Mauritius, show—complete saturation being equal to 100—that there is no period of the year when the humidity of the air, as thus measured, is below 30; and frequently it is as high as 90, when it may be said to show an atmosphere charged with moisture to repletion.

Temperature of the air.

13. The mean annual temperature in the lower parts of the Island, as derived from the published tables of the Royal Alfred Observatory, and deduced from eight years' observations, 1871—78, was 74·5°. The mean of highest readings for five years, 1874—78, being 82.7 °, and the lowest for the same period 65·6°, thus showing an annual mean range for the five years of 16·9°. The *highest and lowest temperature registered* during any day in any month of each of the five (1874—78) years was as follows:—

Year	Highest		Lowest	
1874 ...	... 88°	March 19th ...	61·5°	July 26th
1875 ...	... 87°	December 21st...	61·2°	September 3rd.
1876 ...	... 86·7°	January 3rd ...	57·1°	September 12th.
1877 ...	... 88·5°	January 23rd ...	59·3°	June 25th.
4878 ...	.. 88·8°	January 6th ...	54·6°	July 3rd.
Means	87·8°		58·6°	Range 29·2°.

Annual Rainfall.

14. By the kindness of Dr. C. Meldrum, Director of the Royal Alfred Observatory, Mauritius, we have been favoured with tables of annual rainfall and number of days in which rain fell, and which tables are hereto annexed. From these tables we find that the quantity of annual rainfall, and number of rainy days, have not decreased since observations were first commenced, and which date as far back as 1789. The following resumé will make this clear:—

During six years' observations taken at Port Louis, the mean annual fall of rain was 33·85 inches, and the mean annual number of days of rain was 100.

During a period of eighteen years' uninterrupted observations, taken in the same locality, that is from 1853—70 the mean annual rainfall is shown as 42·74 inches, and the number of rainy days as 128·6.

And for the eight years succeeding, *i.e.*, 1871—78 (extracted from published Blue Books) the mean annual fall of rain has been 54·65 inches, and the mean number of rainy days 203·5. So that far from any decrease being observed in the annual fall of rain, or the number of rainy days, a considerable increase is apparent, during later times, if we compare the means for the three periods.

	Inches.	Number of rainy days.
1st period, 1789, 90, 91, and 1821, 1827 and 1831	33·85	100
2nd period, 1853 to 1870 ...	42·74	128·6
3rd period, 1871 to 1878 ...	54·65	203·5

For stations situated in the interior of the Island, we find the average rainfall to have been as follows :—

Station.	District.	Elevation above sea level	Number of years of observation.	Mean rainfall in inches.	Mean number of rainy days.
1. Mont Choisy	... ...	50	24	47·42	11·65
2. Gros Cailloux .	Black River ...	60	9	33·11	86·5
3. St. Aubin ...	Savanne ...	120	15	86·83	225·6
4. St. André ...	Pamplemousses ...	170	18	47·00	153·6
5. Labourdonnais.	Riviére du Rempart.	300	18	64·62	124·8
6. Gros Bois ...	Grand Port ...	550	16	100·89	234·2
7. Beau Séjour...	Plaines Wilhems...	950	18	71·05	189·9
8. Cluny ...	Grand Port	1,000	16	151·66	266·1
9. Espérance ...	Moka...	1,450	15	124·16	294·3

It will be seen that there is considerable diversity in the mean annual rainfall in each of the above nine stations, and which cannot be accounted for by elevation alone, but which rather depends on which side of the Island the stations are placed as well as on the conformation of the land in their immediate vicinity. These factors must, however, be considered in relation with the direction in which the prevailing winds blow,—and which, when they first arrive, are laden with moisture—both from the south-east quarter as the trades, and the north-west as the monsoons ; and also under the well known law, that as the air is cooled down, so will it part with the moisture it can no longer hold in solution. We have the necessary explanation as to why such diversities in the rainfall should prevail over a comparatively small extent of insular country, so favourably situated as Mauritius is with regard to its georgraphical position.

The following remarks are offered in further explanation of the above :—

During the cool period of the year the prevailing winds are the south-east trades. They are comparatively dry and cold winds, blowing from the Antartic regions towards the Equator, and, meeting in their course, with comparatively no lands to further dry them until they impinge on this Island, their lower strata being considerably warmer and therefore holding a greater amount of moisture in suspension and which is derived from the expanse of waters over which they have blown. Arrived at Mauritius these lower moisture-bearing strata are forced to rise upwards in order to pass over the elevated table lands, and in their assent are cooled down, and hence part with that moisture which they can no longer hold in suspension owing to the fall of temperature due to elevation. Should they pass over headlands, ridges, or mountains, before reaching the median

elevations of the table land, they will have then become considerably drier in the ascent,—it being also observed that the atmospheric air has a capacity for holding water in suspension in direct accordance with its temperature; that when it is at the temperature of 60° of Farenheit's Thermometer, this capacity is doubled to what it could hold at 32°; at 86° it will hold twice as much again as at 60°; and so on. Hence when a warm, and in an oceanic region consequently a moist air, is cooled down to a temperature lower than before, it must part with the moisture which it can no longer hold, and which is then deposited in the form of clouds, rain, fog, or dew. But should the temperature be again raised, it will again dissolve and take up with avidity, to the extent of saturation compatible with the temperature it is at, all the moisture within its reach.

We can, therefore, after considering the above facts, understand why the south-east trade winds, which blow with considerable force, originally arriving laden with a certain amount of moisture, impinging on the high lands of Mauritius, becoming elevated and thereby cooled down, part at the temperature to which they have been lowered, with the moisture which they can no longer retain. And then as they pass away to the leeward side, where they necessarily descend to lower elevations, licking up as it were the train of clouds and mists which they had borne along with them in their passage across the higher parts of the Island.

The north-west monsoons, which arrive from the equatorial regions, and which are consequently warm winds, are laden with moisture to a degree compatible with the higher temperature they have attained. And in proportion as they are cooled down in their passage across the Island is the amount of moisture which they part with greatest. Hence the rainfall is greatest during the season when these winds prevail.

The following, by kind permission of the author, is extracted from one of Dr. C. Meldrum's published works:—

"Generally, therefore, the annual march of the rainfall of Mauritius presents a double progression, having two maxima in February and August, and two minima in June and September. From September to January (the warmest months) the rainfall increases with the temperature, and attains its principal maximum in February, and from February to June, it decreases with the temperature. Instead, however, of decreasing with the temperature in July (the coldest month) it increases, and continues increasing till August, when it has a second maximum before attaining its principal minimum in September.

"It would thus appear that, notwithstanding the diminished evaporation in winter (temperature being regarded as the principal agent) the low temperature of July and August causes a more copious precipitation than takes place, with a higher tem-

perature and greater evaporation, in May and June; or it may be, that the increase of rain in July and August is partly due to an accelerated rate of evaporation in consequence of the strong dry trade wind which then agitates the surface waters of the surrounding ocean."

To which we add the following remarks :—

Another probable explanation of this may, however, be that during the winter the general temperature of the land is somewhat lower than that of the surrounding ocean, and that what little heat there is in it, is then parted with by radiation; so that warmer currents of atmospheric air, arriving from off the ocean on to the Island, would be cooled down thereby, and would thus be forced to part with some of their moisture. Forests, it is now well known, diminish the loss of heat by radiation from the soil; their presence, therefore, would tend to keep the general surface of the land at a more equable temperature, when, in such case, there would be less precipitation during the cooler months of the year, but which is greater in consequence of so little forests now remaining on the Island. Though the mean annual rainfall has increased in Mauritius, the general humidity of the air has diminished with the disappearance of the large primeval forests. Instead of an even saturation of the air with moisture, which forests tend to cause and maintain, it is now variable with a range into extremes.

The following is Dr. Meldrum's summing up of the general distribution of rainfall over the Island :—

"(1.) On either side of the Island the rainfall increases from the coast up to the highest station on that side, and attains a maximum at or near the summit of the eastern declivity, the line of maximum fall extending from near Labourdonnais, in the north, away to the southward, passing, probably, to the east of Espérance and to the west of Cluny, and thence to the neighbourhood of Grand Bassin and the Savanne Mountains, in the south, and along this line the maximum rainfall itself varies, and is greatest in the highest and most wooded parts of the Island near the commencement of the slope towards the east.

"(2). The rainfall on the east coast is from two to three times greater than on the west coast.

"(3). From the east coast westward to the highest stations on the eastern side, the increase of height is to the increase of rainfall nearly in the ratio of 5 to 2, and from the west coast eastward to the highest stations on the western side nearly in the ratio of 5 to 1.

"(4). The rainfall at Espérance, one of the highest stations on the western side, is four times the rainfall at Gros Cailloux on the west coast; and the rainfall at Cluny, the highest station on the eastern side, is a little more than twice the fall at Beau-Vallon and La Gaiété on the east coast, and five times the fall at Gros Cailloux.

"(5). If the other conditions be the same, the nearer the station is to the east coast the greater is the rainfall."

And then he goes on to say: "When the rain from the north-west is general, the relation between the east and west coasts, with regard to the rainfall, is reversed, which shows that the east coast owes its greater rainfall to its being on the windward side of the Island."

Forests of Mauritius, past and present.

15. From an old and very interesting map of the Island, which was published in 1835, by Major F. A. Mackenzie Fraser, and lent to us for the purposes of this report by the Honorable E. Icery, it is seen that at that time nearly two-thirds of the total area of the Island was under primeval forest. There was then an unbroken mass of forest extending from the sea coast in the south, *across to the Calebasse mountains in the north.* The greater part of Savanne district was then under forest, likewise was also Grand Port, and the southern parts of the Black River district.

On the table land itself the forests then had only disappeared from Moka from a point near Mont Thérèse, and westward of it, and at Plaines Wilhems a considerable gap had then been created, while on the low country, and bordering the coast, all forests had been cleared away excepting small plots scattered about here and there, and evidently indicating that the land thus occupied was not culturable; for instance the whole of the Plaine des Roches and other tracts similarly circumstanced. The map from which these details are obtained is well worthy of preservation as showing the condition of the Mauritian forests forty years ago.

We now turn to another map, also kindly lent us by Dr. Icery, which was published in 1872, and mark the contrasts which this map offers in that year to what the other map did as respects the forests in the year 1835—that is, after the lapse of a period of 37 years. The great mass of the aboriginal forests from the central parts of the Island had then disappeared, and likewise they had also receded from the coast upwards into the heights. The whole of Savanne and a great part of Grand Port districts had likewise been cleared. So that from occupying an area equal to two-thirds of that of the Island in 1835, the forests in 1872 were reduced to about 70,000 acres; and at the present day the area of what were once aboriginal forests, but now more or less dilapidated and ruined, is reduced to about one half of the above, *i.e.*, 35,000 acres. With the exception of such forests as the Crown holds, private proprietors, up to the present moment, are actively engaged in still further reducing those areas by extending the cultivation of the sugarcane, and by leasing the right to fell timber and to burn charcoal to the natives of India.

16. We will now describe, after having seen some tracts happily as yet spared, what the aboriginal forests of this Island were like in composition and character, and what a powerful influence their presence must have exercised at one time towards enriching the land, maintaining the waters in the various rivers, and keeping up a general condition of humidity in the air within reasonable limits of their boundaries.

Evergreen forests.

The aboriginal forests of Mauritius may be said to have belonged to the class known as Evergreen Tropical Forest, and which, in the Island at the present day, are represented and reduced to a few isolated tracts, spared because they were either inaccessible, or because they contained no trees yielding valuable timber. The majority of the old primeval forests have however given way, through the agency of man alone, to inferior forest and scrub both as regards growth and composition, but which yet have, in some parts of the Island, acquired, by age and growth, a rank little inferior to the aboriginal productions they had replaced. These forests, of secondary growth, are mainly composed of species which have been introduced by man, and which have now, by time and the genial influences of suitable climate and soil, become subspontaneous; and have moreover, wherever the aboriginal vegetation has been destroyed, occupied its place with a persistency which is remarkable, and a vigor of growth which has left the indigenous inhabitants, wherever they have maintained the struggle, quite in the background; clearly indicating thereby that in the race with them for existence their insular brethren have no chance at least for the present.

Evergreen Tropical Forests are developed in countries lying within the Tropics, possessing climates which are equable as regards temperature, and in which the annual rainfall exceeds 75 inches. In an insular climate, like that of Mauritius, such forests are capable of development in regions where the annual rainfall is less, because of the general humidity of the atmosphere in proximity to the sea. However, in all the elevated parts of Mauritius the annual rainfall exceeds, and far exceeds, 75 inches, as will have been seen from the remarks already given in a preceding paragraph. In these evergreen forests, at all seasons of the year, great dampness of the soil and air prevails; and by the dense, almost impenetrable screen of foliage above, likewise a deep dark shade, so that light is almost excluded from them. The ground underneath is likewise covered over with a vast assemblage of associated species which render progress through such forests impossible, except by clearing paths through them. By the compactness of their growth and a certain special development, they bid defiance to the hurricanes which now and then visit the Island; and, though individual trees, composing the mass of vegetation, may, owing to the

little hold they have of the soil, be overturned by the mere weight of a man leaning against them, yet, owing to the stillness of the air, which at all times prevails within these forests, and is so maintained by the impenetrable mass, that the most fragile twig is as safe from injury from strong and violent winds, as it would be, were it growing in a well constructed hot house. It is this stillness of the warm air, combined with an enriched soil always surcharged with moisture, which accounts for the vast assemblage of species which are usually found occupying their recesses.

In Mauritius these evergreen forests do not attain any considerable height, which is probably due alone to the want of depth in the soil. The tallest trees rarely exceed 60 feet, and the average height is barely over 30; it is at this height that the impenetrable canopy overhead is formed, the taller trees piercing this, and remaining with their crowns considerably isolated in consequence. Such trees invariably develop buttresses, and have fluted and irregular stems in order to withstand the action of strong winds to which they are thus exposed.

The foliage is likewise peculiar, composed of thick leathery leaves with a peculiar gloss on them. The species with such leaves are capable of sustaining the deepest shade with impunity; and it is in this property alone that hope lies that in many forest tracts now occupied by introduced species, the latter will eventually have to give way before the Mauritian species, which however are slow growers.

The species which attain the maximum of height, and which usually yield timber of marketable value are: *Calophyllum inophyllum*, *Canarium Colophania*, *Elæodendron orientale*, *Stadtmannia*, *Sideroxylon*, *Eugenia glomerata*, *Fœtidia mauritiana*, *Sideroxylon grandiflorum*, *Imbricaria maxima* and *petiolaris*, and *Diospyros mauritiana*. Of trees which attain a medium height, and many of which furnish useful building material, may be cited: *Wormia ferruginea*, *Xylopia Richardii*, *Schmidelia monophylla*, *Pisonia culpidia* (the structure of the woody tissues of this is remarkable), *Celtis mauritiana*, *Sponia orientalis* (said to have been introduced), *Ficus mauritiana* and *Ayresii*, and the several species composing the genus *Tambourissia*.

As occupying marshy grounds the following are characteristic species:—

Calophyllum parviflorum, *Labourdonnaisia calophylloides*, *Sideroxylon Bojerianum*, *Stillingia lucida*, *Acalypha colorata*, and *marginata*; and smaller undergrowth, such as *Jussiæa repens*, and *suffruticosa*, *Faujasis pinifolia*—a remarkable species belonging to the order *Compositæ*; *Philippia abietina* which frequently attains a height of fifteen feet; of *Dracæna* and *Pandanus* several species; and *Smilax anceps*.

As composing the main body of these tropical evergreen forests and all loving the damp, humid, rich soils pervading

them, we have the following species, several being endemic :—Of *Anonaceæ* we have *Anona amplexicaulis*, *grandiflora* and *mauritiana*. Of *Bixaceæ*, characteristic species, such as *Erythrospermum mauritianum*, and *Alphloia mauritiana*. Of other genera we have *Pittospermun Senacia*, *Haronga madagascariensis*, *Asteria rosea*, *Dombeya*—several species. *Trochetia triflora*, a tree attaining thirty feet in height, the remaining species of the genus being however mere shrubs. *Ochna mauritiana*—which is endemic. *Hugonia tomentosa*—with its remarkable woody tendrils: *Erythroxylon laurifolium*, *Evodia obtusifolia*, *Zanthoxylon heterophyllum*, *Bursera obtusifolia*, *Quivisia mauritiana*, *Olax psittacorum*, *Cossignya pinnata*, *Doratoxylon mauritianum*, *Cnestis glabra*, *Roussea simplex*, *Grangeria borbonica*. *Weinmannia tinctoria*, *Psiloxylon mauritianum*, *Casearia fragilis*, *Eugenia*—several characteristic species, *Memecylon trinerve* with one or two other species, *Polyscias paniculata* and *Dichrostachys*. The order *Rubiaceæ* is largely developed by such genera and species as *Mussænda arcuata*, and *Landia*, *Fernelia buxifolia*, *Antirrhæa verticillata*, *Plectronia*, *Myonima*, *Coffea*, *Psathura terniflora* and *myrtifolia*. We have likewise *Embelia micrantha* and *Ardisia Sieberi*. Also such species as *Sideroxylon boutanianum*, which grows into a small tree; *Diospyros Tessellaria*, *Chrysophyllos* and *Melanida*—all three of which are endemic. *Olea lancea*, *Ochrosia bourbonica*. Several characteristic species of the genus *Gœrtneria*, *Nuxia verticillata*—a most elegant species when in flower—*Tabernæmontana telfairiana*, *persicariæfolia* and *Mauritiana*. *Colea mauritiana*, *Clerodendron heterophyllum*, *Mespilodaphne cupularis*, *Hernandia peltata*—*Antidesma* (leaves with pitted swelled glands in their axils) such as *A. madagascariensis* and *rotundifolium*, and an undescribed species with opposite or sub-opposite leaves. *A. longifolium* and *Boutonia* likewise occur in the damp evergreen forests. *Phyllanthus anomalus*, *phillyreæfolius* and *lanceolutus*. *Claoxylon linostachys*, *Mallotus integrifolius*. Several species of the genus *Croton* of shrubby virgate habit. Besides the order *Orchidaceæ* which is represented by 23 genera and 75 species. Several palms, which however have nearly all disappeared from the forests, except as immature plants, owing to the upper stem (palm—cabbage) being prized for salads. We have likewise *Flagellaria indica* occurring at all elevations in the damp woods.

Of small herbaceous plants and shrubs, such of them as are implied by the occurrence of *Impatiens Gordoni*, *Phylica mauritiana*, *Dodonæa viscosa*, *Scævola Kœnigii*, *Bryophyllum calycinum* and *Nesea triflora*, likewise occur; also genera and species of the following orders: *Cactacæ*, *Loranthaceæ*, *Compositæ*. *Plantago major* and *lanceolata* also occur in the higher parts of the island. *Ehretia petiolaris*, *Trichodesma*—several species. *Heliotropium indicum*; several species of the orders *Convolvulaceæ*

Solanaceæ, and *Piperaceæ*; of the latter, such as *Piper subpeltatum*, *borbonense* and *sylvestre*; and likewise several herbaceous species of the genus *Euphorbia*.

Of Ferns a large number; *Cyathea canaliculata* and *excelsa*,—the latter attaining to a height of thirty feet in the forests of Grand Bassin; where also occurs the other arborescent Fern, *Dicksonia abrupta*, besides several grass-like species belonging to the natural order *Cyperaceæ*.

In the warmer parts of the Island occur such species as the following:—*Cissampelos Pareira*, *Sida* several species; also genera such as *Abutilon*, *Urena*, *Triumfetta*, *Hibiscus*, *Thespesia populnea*, *Waltheria indica* (which in India usually occurs in dry sandy soils) *Elæocarpus*, two species, and *Ammannia vesicatoria*.

Forests of secondary growth.

17. These forests have been called into existence by the agency of man, who, by felling the aboriginal jungles, and introducing many new and foreign species to the Island, where the latter having found a climate and soil suiting them, have multiplied and overrun every available spot they could fix upon, and from which the indigenous vegetation had been previously removed. These subspontaneous species, in some parts of the Island, form tolerably dense forests which are affording considerable shade and protection to the soil, and are likewise enriching it with their debris. But these forests do not form that impenetrable green canopy above, so characteristic of the evergreen forests. The species which mainly compose these forests of secondary growth are such as *Tetranthera laurifolia* and *monopetala*, *Albizzia Lebbek* and *procera*, *Acacia arabica*, *concinna*, and *Farnesiana*—the latter prevailing in the lower parts of the Black River, *Tamarindus indica*, *Psidium pomiferum* and *Cattleyanum*—the latter forming a considerable proportion in some of the forests. *Eugenia uniflora*, *gambosa*, *malaccensis* and *jambolana*—*Ehretia serrata*, *Cinnamomum zeylanicum*, *Excœcaria sebifera*, *Entada scandens*, and *Ravenala madagascariensis*. The latter forms almost pure forests in the middle part of the Island, east of the Midlands Estate, and which are simply indescribably beautiful in appearance.

As forming dense and impenetrable undergrowths are *Rubus moluccanus* and *Lantana camara*. In fact these two wide-spreading shade-yielding plants have exercised a considerable influence towards ameliorating evil effects of the general deforesting which has been carried out with such vigor in Mauritius, by quickly taking possession of, and shading the soil, and thus preventing insolation which is so destructive an agent in causing decomposition of the vegetable matter (*humus*) of the soil. When the land becomes again covered with trees, these light loving shrubs will then die out; but meanwhile they are serving a useful purpose.

Of other introduced and now generally cultivated species the following are a few of the more prominent, namely :—*Casuarina equisetifolia, Anona muricata* and *squamosa, Cananga odorata, Artabotrys odoratissima, Wrightia tinctoria, Alstonia scholaris, Tectona grandis, Ficus bengalensis, macrophylla,* and *religiosa, Pithecolobium dulce, Dillenia speciosa, Castanospermum australe* (the Moreton-Bay Chesnut) several species of Eucalypts, *Hiptage Madablota, Hæmatoxylon campeachianum, Cæsalpinia Bonducella, sepiaria* and *Sappan, Terminalia Arjuna* and *Catappa, Persea gratissima, Melia Azedarach, Flacourtia Ramontchi, Reinwardtia trigyna, Moringa pterygosperma, Citrus Hystrix* (now naturalised) *Erythrina indica, Parkinsonia aculeata, Adenanthera pavonina, Berrya Ammonilla, Bassia longifolia, Spondias dulcis, Phyllanthus distichus,* the mulberry, *Jatropha Curcas* and *multifida, Euphorbia Tirucalli, Aleurites moluccana, Ananassa sativa* (now quite wild), *Lodoicea Seychellarum, Pandanus utilis,* the Vanilla, several species of bamboo, and *Panicum acariferum* which forms splendid hedges in the higher parts of the Island. Also such trees as the Jack, the Bread Fruit, Mango, Litchi, Peach, Plantains and Bananas, Cocoanut and a great variety of other edible fruit-bearers.

Of small growths are :—*Argemone mexicana, Cardiospermum Halicacabum, Psoralea corylifolia, Crotalaria*—several species. *Tephrosia purpurea, Wikströmia viridiflora* (now naturalised), *Cassia,* several herbaceous species, &c., &c.

The season of vegetation, as regards the indigenous flora, is continuous all the year round, there being, however, a general shedding and renewal of leaves during the cooler months of the year. As regards introduced species, which are chiefly of deciduous habit, they follow the general law of such species, and are deciduous during the months of July and August, even at a period when there is a considerable quantity of rain falling, and while the air and the soil are both charged with moisture.

In the structure of the wood, of evergreen indigenous species, no clearly defined annual rings of growth can be discovered ; and this is the case with all the Mauritian species of which the timber is valued. Hence no remarks are offered as to annual rate of growth ; but judging from the rate of growth observed in introduced species, it must, compared with these, be slow,—no measurements of actual rate of growth being however available.

Forest Revenue and Expenditure for 5 years, 1875-79.

The total revenue for the five years was Rs. 39,660, of which the heaviest item was on account of leases for the right of shooting on Crown lands, namely Rs. 13,206 ; and next to that by sale of timber to a contractor Rs. 10,540.

The total expenditure was Rs. 1,48,503, salaries occupying the largest share of it, namely, Rs. 88,256 ; the next heavy item is on account of plantations, namely, Rs. 35,032 ; and various

other sums for raising young plants, planting up school premises, &c. The cost of uniform for forest rangers is put down at Rs. 6,712, and for hutting and medical treatment of the force, Rs. 2,638. *(To be continued.)*

IV. Notes, Queries, and Extracts.

Paper from Coniferous Trees.—To make a pliable and merchantable paper from the bark of coniferous trees it is necessary to exhaust, or nearly exhaust, the intercellular or tannic substances therefrom, since, if they are retained, the paper produced will be harsh and hard, and will have a stiffness like parchment, such intercellular or tannic substances acting as a "size" to stiffen the paper, and if the stock is subjected to heat, it will become discolored and cannot be thoroughly bleached. It has also been found that to extract the intercellular or tannic substances it is necessary to treat the bark of coniferous trees with cold or tepid water, since, if treated with hot water or steam, the stock becomes discolored.

This process, therefore, consists in exhausting, or nearly exhausting, the intercellular or tannic substances from the bark of coniferous trees by treating the same with cold or tepid water; further, in a pulp made from the bark of coniferous trees having the intercellular or tannic substances exhausted, or nearly exhausted, therefrom; further, in the process of making paper pulp from the bark of coniferous trees, consisting in treating the bark with cold or tepid water, macerating such bark either before or after the treatment with cold or tepid water, and then bleaching the stock. The invention therefore consists in the paper, as a new article of manufacture, made from the barks of coniferous trees with the intercellular or tannic substances exhausted, or nearly exhausted, therefrom. This paper is very pliable and tough, light in color (if bleached,) and smooth and fine in texture. It can be readily distinguished by experts from the paper previously made from the bark of coniferous trees wherein the intercellular or tannic substances were retained as a size, as the last mentioned paper is stiff and harsh, presenting a different appearance to the eye, and a different feeling to the touch.

The bark of the coniferous trees preferably macerated by any of the ordinary methods, or taken from the trees without maceration, is put at once into the pulping engines, where it is beaten and thoroughly washed by passing through it a stream of cold or tepid water continuously. The coloring matter peculiar to this paper stock and to no other, which is highly soluble in water, is driven into the water and carried off by this operation, which should continue from four to ten hours. Gallo-tannic acid, one of the injurious constituents of this stock, decomposes and darkens at a temperature of 160°

Fahrenheit; therefore the temperature of the water in the engines should never exceed that degree of heat, the best temperature being about 80° Fahrenheit. At the expiration of this operation the pulp is ready at once to be run into paper in the usual way.

If it is desired to lighten the color of the pulp it may be acidulated by some dilute acid, preferably sulphuric acid. This acid is then washed out, and the pulp then run into paper in the usual way. For very light colored and white papers *the pulp should be treated to a solution of chlorinated alkali*, preferably chlorinated soda, the strength of this solution depending on the degree of whiteness desired. It has been found in bleaching this stock that it is obstinate under treatment when chlorine alone is held in the water; but as soon as the little soda or potash is thrown in, the stock begins to bleach at once. The slightest degree of strength of alkali in the solution improves the color of the pulp, and the greatest degree of strength does no injury.

By this treatment, in the first instance, of water of the temperature described, the color of the bark stock is lightened as the intercellular or coloring matter in the bark is washed out, thus avoiding the injurious effect of boiling, by which latter operation the color is set and the rosin fused, thus cementing the fibres together, and effecting the color of the *pulp very badly. This species of bark, although easily* bleached as a whole by the above-described method, is apt to retain clusters of fibres of the outer bark, which resist the process of bleaching, and appear as red hairs in a ground of white or very light paper. In order to treat such bark properly and completely, when a white or nearly white paper is wanted, the disfibred bark, after the treating and washing described, is boiled in lime water from four to sixteen hours, the time being regulated by the amount of lime used, which varies from one to four barrels to two tons of stock. After this boiling, the bleaching, if any is requisite, is performed as described.—(*Paper Maker's Journal.*)

USES FOR WASTE SAWDUST.—Until a few years ago the enormous "lumber" trade of North America took things pretty well as it liked, and so long as those engaged in the industry could find a location on the banks of a fair-sized stream, which was not very difficult in that well-watered country, they did not experience much trouble in conveying to the great centres of consumption all the timber they could cut. The river afforded, not only an easy means of conveying their produce to market, but abundant power for driving their saws, and also formed a convenient receptacle for the sawdust which they produced in enormous quantities. But various

interests found the presence of the sawdust a serious objection—notably the fishing industry; and both in Canada and the United States the Legislature stepped in to prohibit the casting of sawdust into any running stream under heavy penalties. At the same time various causes—such as the competition of coal, the exhaustion of the forests closely adjacent to the river, and the consequent increase in cost of production and decrease in value—combined to reduce the profits of the lumberers, who thus found themselves under the necessity of getting rid of their refuse sawdust in some more costly manner than by merely casting it into the stream. The same duty is of course thrown on the owners of all saw mills; and, as it is calculated that at Minneapolis alone the quantity of sawdust produced in a single season is equal to about 300,000 cords of solid timber, each "cord" being equal to 128 cubic feet, the rapid accumulation of the refuse material in different parts of the Continent may be better imagined than calculated. The "millers" are looking about for a profitable mode of utilising this product. Burning it as fuel for their steam-engines makes no appreciable diminution in the supply; and, though various means of turning it to good account have been suggested, their adoption is not always practicable on the spot. Mixing the sawdust with tar or pitch, and converting it into fuel, has been found to answer in some cases; in others the manufacture of "fire lighters," by mixing the sawdust with petroleum or resin, and pressing into small cakes, has been adopted. An ingenious American inventor has devised a machine for working up the material into a pulp and compressing it into various shapes, such as barrels, brackets, doors, &c. It is said that articles of furniture made in this way are in certain respects preferable to those made of ordinary wood, the pulp becoming prefectly hard and impervious to water. It is not improbable, therefore, that—as has already happened in this country—the prohibition placed on the throwing of refuse into the streams may result in the establishment of new and profitable industries.—(*Paper Maker's Journal.*)

Query:—EUCALYPTI.—Have any experiments been made with the different species of Eucalypti to discover their floating powers?—RIVERINE.

READING a note by "P. K." on the effects of *staining* oak wood by lime water reminds me of a very beautiful "teapoy" of "walnut" wood which had been stained perfectly black by the same method. The water must be applied with a fine brush, and allowed to dry perfectly before another coating is applied. French polish is then used in the usual way.—RIVERINE.

THE attention of the Russian authorities like that of the Bombay Government has lately been turned to the prejudicial manner in which certain districts have been affected by the wholesale destruction of trees. From the earliest ages, the vegetation in the valley of Samarcand, and generally of the districts of Saraf-jansk and Sagdiana, has been so luxuriant, and the climate so mild and pleasant, that it has been compared by Persian poets to paradise, and so fertile is the whole oasis, one of the largest in Central Asia, that it produces not only sufficient corn for the subsistence of its 30,000 inhabitants and of the 9,000 troops quartered in it, but is also able to export large quantities of rice and wheat every year to Bokhara. During the last ten years, however, the climate has become sensibly worse, and this deterioration is believed to be mainly attributable to the reckless way in which the forests have been cut down, and extensive tracts entirely denuded of trees, partly by the native inhabitants, who burn down whole woods in order to obtain charcoal easily, and partly by the Russians to procure the building material they required when they took possession of the territory. Energetic measures are, however, a correspondent of a German paper states, now being taken to arrest this wholesale destruction. The felling of trees for conversion into charcoal, or to float down the river to Bokhara, is strictly prohibited; and a decree has also been issued that a certain number of trees are to be planted on every acre of irrigated ground as well as on the banks of the streams and canals. In pursuance with this order no fewer than 11,750,000 young trees were, it is said, planted last spring, in the district of Samarcand.—*Indian Agriculturist.*

THE following are the only extracts from the Report of the Lucknow Horticultural Garden for 1879-80 of any interest to our readers :—

Carobs.—This year the carob trees bore a very light crop, only 3½ seers of seed were obtained. The pods were much softer and sweeter than in previous years, owing, doubtless, to the mildness of the season and absence of hot winds when ripening.

Repeated attempts were made to raise plants by budding on seedling stocks; buds were inserted in different months, but I regret to say all failed: but for a limited number of stocks budding would have been tried all the year round. Grafting by inarching was also tried, but, like the budding, was unsuccessful. When a supply is ready fresh attempts will be made.

Eucalypti.—These call for no special notice. The plantation mentioned in previous reports continue to flourish. One tree of *E. citriodora* flowered, and a few seed capsules formed; it remains to be seen if mature seed will be developed.

As the name of *E. saligna* was not known when first noticed, specimens of it were submitted to Baron von Müller and Sir Joseph Hooker for identification. Both pronounced it to be *E. resinifera*. In a letter received from Baron von Müller last July, he writes :—"While working on my *Eucalyptus* atlas I find this species approaching rather to *E. robusta*, but there are characteristics to separate it from either, and I have temporarily named it *E. Kitorniana* in honor of its discoverer who found it at Illowarra, the *only locality in which it is known* in a wild state." Considering that it has already been distributed under two names, it seems undesirable to add a third, especially as it is only a temporary one; confusion is likely to result by so doing, which will be avoided by adhering to the present name.

Resin and Turpentine.—The following account of the mode of production of resin and turpentine on the south-eastern coast of the United States is taken from an American paper :—"From Wilmington, N. C., southward, and nearly all the way to Florida, the pitch pine trees, with their blazed sides, attract the attention of the traveller. The lands for long stretches are almost worthless, and the only industry, beyond small patches for corn or cotton, is the 'boxing' of the pitch pine trees for the gum, as it is called, and the manufacture of turpentine and resin. There are several kinds of pine trees, including the white, spruce, yellow Roumany, and pitch pine. The latter is the only valuable one for boxing, and differs a little from the yellow pine, with which it is sometimes confounded in the north. The owners of these pine lands generally lease the 'privilege' for the business, and receive about 125 dols. for a 'crop,' which consists of 10,000 'boxes.' The boxes are cavities cut into the tree near the ground in such a way as to hold about a quart, and from one to four boxes are cut in each tree, the number depending upon its size. One man can attend to and gather the crop of 10,000 boxes during the season, which lasts from March to September. About three quarts of pitch or gum is the average production of each box, but to secure this amount, the bark of the tree above the box must be hacked away a little every fortnight. Doing this so often, and for successive seasons, removes the bark as high as can be easily reached, while the quality of the gum constantly decreases, in that it yields less spirit, as the turpentine is called, and then the trees are abandoned. The gum is scraped out of the boxes with a sort of wooden spoon, and at the close of the season, after the pitch on the exposed surface of the tree has become hard, it is removed by scraping, and is only good for resin as it produces no spirits. The gum sells for 1·50 dollars a barrel to the distillers. From 16 barrels

of the crude gum, which is about the average capacity of the stills, 80 gallons of turpentine and 10 barrels of resin are made. The resin sells for from 1·40 dols. to 5 dols. per barrel according to quality, and about pays for cost of gum and distilling, leaving the spirit, which sells for 40 cents. a gallon, as the profit of the business. Immense quantities of resin await shipment at the stations along the line, and the pleasant odour enters the car windows as we are whirled along. After the trees are unfit for further boxing, and are not suitable for lumber, they are sometimes used to manufacture tar, but the business is not very profitable, and is only done by large companies, who can thus use their surplus labour. The trees are cut up into wood, which is piled in a hole in the ground and covered with earth, and then burned in the same way as charcoal is burned elsewhere. The heat sweats out the gum, which, uniting with the smoke, runs off through a spout provided for the purpose. A cord of wood will make two barrels of tar, which sells for 1·50 dols. per barrel, and costs 37½ cents. to make. The charcoal is then sold for cooking purposes."—*Indian Agriculturist.*

TIMBER OF BRITISH GUIANA.—A meeting of the Royal Geographical Society was held recently in the theatre of the University of London, Burlington Gardens, the Earl of Northbrook, First Lord of the Admiralty, occupying the chair.

Mr. Everard F. im Thurn read a paper describing an expedition which he made into the interior of British Guiana in 1878. He explained that during the last three years he had been superintending the museum at Georgetown, more commonly called Demerara. Collecting for the establishment, he had made several journeys into the interior of the country. The country might be said to consists of four tracts, lying one beyond the other parallel to the coast. Of these only the outermost, the sugar land, was at present cultivated and inhabited to any considerable extent. Next came the timber tract, which was merely inhabited by a few Negroes and Indians. It once contained much valuable timber, which was readily brought to market, but that had now been felled and destroyed, and it was no longer easy to find any spot where it would be worth while to set up the large and expensive plant necessary for remunerative timber cutting, so that, unless the forests were allowed to recover, the timber trade of the colony must ere long come to an end. The forest tract immediately succeeded the timber tract, and was uninhabited except by a few widely-scattered Indians of four or five different tribes. It was everywhere covered by dense forests, as yet untouched by the woodcutter, and consisted largely of the two most valuable trees of the colony—the green heart and the mora. The

last tract was formed by the savannahs of the interior, which must be distinguished from the so-called savannahs of the coast and forest regions. Our share of this huge meadow was about 1,400 square miles in extent.

THE EXTINCTION OF THE PINE.—In no way, says the *Boston Transcript*, have the wasteful habits of Americans been more conspicuously shown than in their utter disregard of all economy in utilizing the rich stores of pine timber which our virgin forests afforded. We say afforded advisedly, for such has been the utter recklessness with which these have been felled and destroyed that, compared with the needs of the country, the white pine within hauling distance of the rivers of New England has very largely disappeared, and if, back from the streams, large and valuable trees of this variety are still found standing, they are marked for an early attack of the wood-man's axe, for white pine of good quality no longer ranks among cheap woods, but pays a handsome profit to the lumberman over and above a very considerable outlay for handling and hauling. On the other hand, on account of the ease with which it can be worked, its regularity and straightness of grain, its lightness, and its peculiar adaptability to thousands of purposes, white pine comes daily into greater and greater demand, and it is one of the serious problems with which the near future must deal to know how to find the needed supply. It is very certain that at the present rate of waste and consumption the supply of available white pine lumber will in a few years be nearly exhausted, and that if steps are not taken to create a new supply, and that speedily, a lumber famine will be upon us. Of hard pine the south, especially Florida and the Carolinas, have an ample store, more than will suffice, even if cut in the present wasteful way, for generations to come; but white pine, which, were it not that it has been so common in the past in New England, we should prize as one of the most valuable woods, is daily becoming more and more scarce, and he who is fortunate enough to possess a tract of pine land, even though of limited extent, may well feel that he has a "bonanza," with the value actually in sight and available, and without any of the uncertainties that attach to properties classed as "mining," where the ore can be counted upon only as far as it can be seen, and may "pinch out" most unexpectedly at any moment. Over the waste that has already occurred, over the millions upon millions of feet that have been allowed to decay or to succumb before forest fires, it is useless to indulge in regrets, but it does seem as though those engaged in the lumber business would find it for their interest to introduce more economic methods of husbanding what remains, and

of securing the largest possible yield in "board feet" from each tree hereafter.

> "It so falls out
> That what we have we prize not to the worth
> While we enjoy it; but being lack'd and lost,
> Why then we rack the value."

And so it is with our New England pine. We have seen it about us from boyhood up; we have whittled it and wasted it; we have used it for kindling, and enjoyed the sharp, quick crackle of its blaze; we have used it for all sorts of purposes, but we have never realized either its beauty or its superior advantages as lumber.

We wisely appoint and maintain at the public expense a fish commission to apply the teachings of science and experience to the re-stocking of our rivers and ponds, and establish and execute stringent laws for the protection of the small fry until they are old enough and numerous enough to protect themselves from extermination. In some such way something might and should be done to protect our forests, especially those of white pine. The great trees that have attained their maturity may well be felled, but those younger in years and of a smaller growth should be protected from the vandal hands that ruthlessly lay them low for the purpose of "clearing up," and in the end this protection would be found to pay an hundredfold. Moreover, forestry has made its advances along with the other sciences, and it is believed that plantations of young pine trees, set out in proper soil and surrounded with proper conditions, would, in time, return a handsome yield to the investor who can afford to wait for it. In the west a bounty, generally in the form of land from the public domain, is given to those who set out trees. There is no public land in New England to be bestowed in this way, but if the pine-growing states in this corner of the country would institute experiments, and provide the means for the necessary tests, we believe that farmers and others could be made to see that it would be for their ultimate advantage, not only sacredly to preserve every growing pine tree on their lands, but to set out young trees—a few every year. They might not live to see them mature, but they could leave no better inheritance to their children, none that would make a handsomer return upon the investment, than a grove of vigorous and rapidly-growing pines. There are thousands of acres in Massachusetts, now practically valueless, that might profitably be applied to this purpose, and in New Hampshire and Maine whole townships, which have been robbed of their pine, and now yield no return whatever to their owners, might, by gradual planting, at a cost comparatively small, be turned into rich and ever-increasing deposits of wealth, upon which future generations might and would make liberal drafts. We are mining and "preparing"

our anthracite in a way so wasteful and at a rate so rapid that in a score of years this great staple fuel is likely to be scarce and high, with no possibility of renewing the supply. An equally extravagant waste and equally rapid production are destroying our pine lumber. But in this case renewal is possible, and it behoves us to see to it that this important element of future prosperity is not neglected. And the time to move in the matter is now.—*Timber Trades' Journal.*

THE following extract is from the Report on the Inland Trade of British Burma for 1879-80, published in the *British Burma Gazette* for October 23rd, 1880:—

Timber.

The value of the timber imported during the year by the Irrawaddy was only £9,575, compared with £23,063 in 1878-79. This decrease affords strong evidence of the exhaustion of the more accessible teak tracts. The river rose to an extraordinary height during the rains, and if there had been more timber to float out, the facilities for doing so were unusually good. An unhealthy season, with sickness amongst the foresters, and the want of elephants, also contributed to the smallness of the out-turn. The Toungoo timber trade, which is much more extensive than that on the Irrawaddy, also fell off very seriously, the value of the imports having been £99,612 only, as against £196,852 in the previous year, when, however, a great quantity of inferior timber was floated down. Endeavours have been made to find out the condition of the King's forests beyond Toungoo, but no satisfactory information has yet been obtained.

GUTTA-PERCHA.—To the Editor of the *Ceylon Times.* Extracted from the *Indian Agriculturist.* Sir,—Some time since a letter appeared in your journal on the subject of gutta-percha. As I have also taken some interest in this product, I am now enabled to send you the following few remarks on its cultivation, &c. The gutta taban, or tuban trees, are found in Sumatra, Johore, Java, Borneo, and in Singapore, extending over a tract of country from 6° to 10° N. lat. to 10°S. lat., and from 100° to 120° E. long.

The tree (tuban) has a straight stem from 60 to 30 feet, growing to a height of 100 to 120 feet, and when fully grown is from 2 to 3 feet in diameter. The wood of the tree is soft, fibrous, and spongy, of a pale yellow, and marked by black lines consisting of reservoirs filled with the gum. The yield of a large and full-grown tree is sometimes 23 cattys or 17¼lbs. It is generally estimated that 10 full-grown trees will yield 1 picul of gutta-percha or 133⅓lbs. The pure gutta-percha is worth some 2*s.* 6*d.* to 3*s.* 6*d.* per lb. The old and destructive method of collection was to fell the tree and to ring

it with an axe at intervals of 3 to 18 inches, the milk being collected in cocoanut husks, &c., and boiled to draw off the water. The soil most suited to the gutta taban is precisely such as we have in Ceylon; the tree thrives well on naturally well drained hill-sides and in a free soil, and at a considerable elevation. The great drawback to its cultivation is, that it is a very slow grower, taking nearly thirty years to arrive at its full growth, when it is about three feet in circumference, at a height of three feet from the ground. The seeds readily germinate, and the best method of putting out the plant is in bamboo pots, as the tap-root is long, and impatient of any injury. Gutta-percha is entirely distinct from caoutchouc. It reaches the English market from the Straits in three different preparations; the first being boiled milk, of pink color, hard and tough and mixed with bark and other natural impurity; the second, gutta-muntah, being a preparation of gutta reboiled up with cocoanut oil and inferior juices (such as that of the mudar tree, which grows commonly in Ceylon); and the third is the crude gutta-percha, being simply the milk, hardened without any process whatever. The gutta-percha of commerce consists of pure gutta and 15 per cent. of a soft resin mixed with it—the resin has the simple chemical action of absorbing oxygen, without which property, light, such as the sun's rays, would render the gutta brittle, friable, and resinous; it is known that in submarine cables line gutta-percha does not sensibly decay, being protected from the light.—*Pioneer.*

FOREST-SAVING IN AMERICA.—A good deal has been written in our columns about the depletion of the forests of the North American continent; and, though in the sense of a supply of timber for the purposes of trade running short we do not believe that the present generation will witness anything approaching that consummation, we are none the less conscious that the process of destruction is in our day carried on with needless prodigality. We are, therefore, glad to learn that the American Association for the Advancement of Science is about to take steps for preserving the forests in the United States, and for *the protection from waste of timber generally.* A *committee* has been appointed for the purpose of promoting these objects. The attention of Congress and State Legislatures is to be called to the great and increasing importance of providing by adequate legislation for the protection of the existing woodlands of the country against needless waste, and for the encouragement of measures tending to a more economical use and proper maintenance of the timber supply, it being evident that the forests of the country are being used and wasted in a much greater degree than their restoration by natural growth. The committee, in a report they have just presented to the Association,

recommend the enactment of a law to protect trees planted along highways, and to encourage such plantings by deductions from highway taxes; also the passage of a law that shall exempt from taxation the increased value of land arising from the planting of trees where none were growing, for such period as may appear proper, or until some profit may be realized from plantation; by appropriations of money to agricultural and horticultural societies, to be applied as premiums for their planting, and for prizes for the best essays and reports upon subjects of practical forest culture; by encouraging educational institutions to introduce courses of instruction having reference to practical sylviculture; by laws tending to prevent forest fires; by imposing penalties against wilful or careless lighting of such fires, and enlarging and defining the powers of local officers in calling for assistance and in adopting measures for suppressing them; by establishing under favourable circumstances model plantations; by the appointment of a Commission of Forestry under State authority, analogous to the Commission of Fisheries.

Whether this praiseworthy effort of the Association will meet with the encouragement it deserves from the legislative authorities and secure the ends it aims at, remains to be seen. Great bodies move slowly, and many projects of this kind have been urged on Congress before, but we never heard that anything came of them.

PRESERVING TIMBER IN THE GROUND.—In speaking of the well-known methods of preserving posts and wood which are partly embedded in the earth, by charring and coating with tar, it is said these methods are only effective when both are applied. Should the poles only be charred without the subsequent treatment with tar, the charcoal formation on the surface would only act as an absorber of the moisture, and, if anything, only hasten the decay. By applying a coating of tar without previously charring, the tar would only form a casing about the wood, nor would it penetrate to the depth which the absorbing properties of the charcoal surface would insure. Wood that is exposed to the action of water or let into the ground should first be charred, and then, before it has entirely cooled, be treated with tar till the wood is thoroughly impregnated. The acetic acid and oils contained in the tar are evaporated by the heat, and only the resin left behind, which penetrates the pores of the wood and forms an airtight and waterproof envelope. It is important to impregnate the poles a little above the line of exposure, for here it is that the action of decay affects the wood first, and where the break always occurs when removed from the earth or strained in testing.—*Mechanic.*

THE October number of the *Revue des Eaux et Forêts* announces the retirement of both M. Nanquette, the Director, and M. Mathieu, the Professor of Natural History at the Forest School of Nancy. M. Nanquette will be succeeded as Director by M. Puton, whom many of us knew as the Professor or Assistant Professor of Forest Law, and who is besides well known for his writings on 'Amènagement.' The successor of M. Mathieu has not yet been appointed; we presume it will be M. Fliche.

MONUMENT TO FOREST DIRECTOR BURCKHARDT.—We have received a Circular, signed by several eminent Forest Officers and other friends of the late Dr. Burckhardt, saying that a committee has been formed at Hanover for the purpose of erecting in a forest near that town a monument to commemorate the life and work of a man who was distinguished both as a forester and as an administrator. Contributions will be received by Forest Minister Kraft in Hanover.—D. B.

WE are sorry to say that the author not having sent us in time the manuscript of the second portion of his paper on Frosts and Forests, we must defer completing it till our next issue.

V. TIMBER MARKET.

The following have been the prices of Teak and the stock in hand at the Public Docks in London during the last quarter of 1880, compared with the corresponding period of former years:—

Prices.

	1879.	1880.
	£ s. to £ s.	£ s. to £ s.
1st October ...	8 10 „ 10 10	13 10 „ 14 10
1st November ...	9 0 „ 10 15	13 10 „ 14 10
1st December ...	12 0 „ 13 0	13 10 „ 14 10

Stock at the Public Docks in loads of 50 cubic feet.

1st October ...	11,900	8,200	3,400
1st November ...	11,900	7,400	3,200
1st December ...	10,100	6,200	2,600

The figures are taken from Messrs. Churchill and Sim's Monthly Circulars. The great rise in prices and the reduction in the quantity of timber in stock are remarkable.

D. B.

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Nancy Forest School.

MOST of our readers will have learnt ere this that great changes have lately taken place at the Nancy Forest School. M. Nanquette, who presided over the Institution as Director for more than 20 years, and under whose direction many of our Indian Forest Officers have received their professional education, retired on his pension in October last, having attained the prescribed age of 65 years, and M. Mathieu retired at the same time. M. Mathieu was a few years older than M. Nanquette, but the Government requested him to remain, in order to complete the arrangement of the rich collection of woods and other forest produce, which have increased much of late years, notably by the addition of our collection sent from India to the Paris Exhibition in 1878.

It is no disparagement to the merits of their successors to say that the retirement of these two distinguished officers will be felt as a great loss to the Forest School, and the friendly interest with which M. Nanquette and M. Mathieu directed and assisted the studies of the English students will long be gratefully remembered by many Forest Officers in India.

The President of the French Republic has appointed M. A. Puton as Director of the School. M. Puton received his professional education at Nancy, and, after being employed during a series of years in the active service, was appointed to succeed M. Meaume as Professor of Jurisprudence. In French Forest Literature, M. Puton's name is well known by several manuals and other books, the first of which was his "*Service Administratif des Chefs de Cantonnement,* which appeared in 1870. He also published a brief and popular manual, chiefly intended for the use of Subordinate Officers and private proprietors of forests, and entitled, "*Aménagement des Forêts,*" a second edition of which appeared in 1874. Quite lately, in 1880, he published with M. Guyot, the Assistant Professor of

Jurisprudence, a small book entitled, "*Contrainte par Corps en matière criminelle et forestière.*"

Of the other changes which have been made at the School, it will suffice to mention that M. Bagneris has succeeded M. Mathieu as Deputy Director; that M. Fliche has become Professor of Natural History; and that M. Guyot has replaced M. Bagneris as Director of Studies.

M. Puton, writing on 26th November, speaks in high terms of the "promotion" of 1880, and says they were all to be young men who mean to work hard and to push their way in the world.

D. B.

Report on the Forests of Mauritius.

BY R. THOMPSON, *Deputy Conservator of Forests.*

(*Continued from* p. 241.)

PART II.—DESCRIPTIVE AND FOREST MANAGEMENT.

Preliminary Remarks.

BEFORE proceeding with a detailed description, and rules for the future management of the various forest properties of Mauritius, it will be as well to take a brief notice of the Ordinances under which the creation and protection of some at least of these properties are carried out.

Forest laws of Mauritius.

The laws which govern forest property, both public and private, in this Colony, are contained in Ordinance No. 18 of 1874 (as amended) and Ordinance No. 13 of 1875; the latter consolidating, as it were, all previous enactments of the same nature. These two Ordinances, therefore, constitute the whole forest laws of Mauritius, in so far at least as we are concerned with them.

Ordinance No. 18 of 1874.

Ordinance No. 18 of 1874, as amended by Ordinance No. 15 of 1875, regulates the sale of Crown lands, and excepts from such sale, the strip of land round the coast known as the "Pas Géométriques," and the Mountain and River Reserves, when such are the property of Government. It provides, however, for the lease of the "Pas Géométriques," but only on condition that the land is planted with trees within a period of five years, and at the annual rate of *one-fifth* of the land so leased. It also provides heavy penalties for any breach of the conditions of con-

tract of lease, and it empowers a lessee to cut and remove trees of twenty years' growth, but not more than *one-tenth* of the trees during any one year, provided and on condition also that the land so denuded be at once replanted. Heavy penalties are provided in the case of any breach of these conditions. It, however, empowers a lessee to apply for and obtain the sanction, in writing, of the Surveyor-General, to thin and prune his trees.

It prohibits the free grant of Crown land, except when such land is required for religious, charitable or educational purposes, when a grant or concession at nominal rates, is permitted, and for so long only as the land is applied to such purposes.

It likewise provides that sales of Crown lands shall be by public auction; and the leases of such lands shall be granted either by public competition or by private contract. It also prescribes the method of procedure to be observed in all such cases.

It prohibits the grant of *jouissances* limited or unlimited; and lays down the action to be taken with reference to squatters on Crown lands. It requires that the Surveyor-General shall watch over Curatelle lands; and appoints him to be the chief executive Forest Officer in the Colony, with powers to appoint, dismiss or otherwise punish Forest Rangers. All Forest Rangers are required by this law, on being appointed, to be sworn before a Stipendiary Magistrate. The Surveyor-General may likewise appoint Forest Keepers to watch over the forest lands of private owners on their so requiring. Rules are prescribed for the engagement of Forest Rangers before the Stipendiary Magistrate of Port Louis; no Forest Ranger being engaged for any longer term than two years. A notification of all appointments of Forest Rangers, or Forest Keepers, is required to appear in the Government Gazette; and such notice of appointment is considered sufficient evidence, before any Court of Justice, as to the right of such Forest Ranger or Forest Keeper to enforce the provisions of the Ordinance.

It likewise enacts that the Police Force of the Colony shall at all times have the same rights and duties as Forest Rangers; and that every Forest Ranger, Keeper or other person qualified to act as a Forest Ranger, shall be deemed a public functionary.

Ordinance No. 13 of 1875.

Ordinance No. 13 of 1875 is, however, more comprehensive in its scope, and may be considered the law governing all classes of forest property in the Island. Its provisions are judicious, and are so framed as to meet all the varying and peculiar conditions of the people and the properties it purposes to protect and to deal with. It confirms the office of Surveyor-General as the Chief

Executive Forest Officer of the Colony. The following is an outline of this excellent and comprehensive Forest Code :—

Chapter I deals with definitions and interpretations of Crown lands; Pas Géométriques; Mountain Reserve Line; Mountain Reserves, Base Line; *Mountain Range, River Reserves;* Marshes, &c., &c.;

Chapter II makes provisions for dealing with the destruction of timber caused on Reserves, Plantations and Forests;

Chapter III deals with the survey and demarcation of Mountain Reserves;

Chapter IV empowers the Governor in Executive Council to make Regulations, from time to time, for the purpose of carrying out the provisions of this Ordinance, and to alter or revoke the same;

Chapter V makes provisions for enforcing and carrying out of the law; and

Chapter VI lays down the legal procedure to be observed.

These six chapters contain all the necessary Legislation that it is possible to desire, or likely to be wanted in Mauritius for many years yet to come. It may, however, be necessary to consider whether the articles, referring to River and Mountain Reserves, will not require amendment, the reasons for which will be given later on.

Existing Forest Establishments.

The following sketch shows the establishments employed, under existing circumstances, for forest protection and management in Mauritius:—

The Protective Establishment consists of a force, on the permanent staff, of 30 Forest Rangers, headed by an official styled the Guardian of Woods and Forests. This Protective Establishment is directly subordinate to the Surveyor-General, and receiving its orders direct from him. In addition to and exclusive of the above force, and with the control of which he has nothing to do whatsoever, is appointed a Director of Woods and Forests. The duties of this officer appear to be that he is required to carry out the work of raising plantations, restocking the natural forests with the more valuable kinds of trees, has charge of existing plantations and the working of the Crown forests.

The establishments employed to aid him in carrying out these duties being of a temporary nature, are charged to such works. As the Director of Woods and Forests is technically a trained officer, for he is also the Director of the Royal Botanical Gardens of Mauritius, it does appear anomalous that one of the principal duties of a Conservator of Forests should not vest with him, but with the Surveyor-General. However, since the law has appointed the latter Chief Guardian of Woods and Forests, the arrangement must stand.

Constitution of the Forest Force.

The following is the constitution of the Forest Force and its yearly cost to the Colony:

					Yearly Salary.
1 Guardian of Woods and Forests				...	Rs. 1,500
2 I Class Forest Rangers at		Rs.	1,080	...	„ 2,160
2 II Class Forest Rangers		„	900	...	„ 1,800
5 III Class	do.	„	700	...	„ 3,500
2 IV Class	do.	„	480	...	„ 960
19 IV Class	do.	„	360	...	„ 6,840
Total annual cost				...	Rs. 16,760
To the above should be added the annual salary allowed to the Director of Woods and Forests				...	Rs. 1,200
Making a total charge of				...	Rs. 17,960

In addition to the above establishments there are what are called Keepers of Crown and Curatelle lands. It is believed that at present there are three, if not four, such officials, appointed and paid by the Surveyor-General.

Distribution and duties of Forest Rangers.

The distribution of the Forest Force is as follows, and is given here only in the abstract:—

District of Port Louis—area 10 square miles	...	1 II Class Ranger. 3 IV do.
Total	...	4
District of Moka—area 68 square miles	...	1 I Class Ranger. 2 IV do.
Total	...	3
District of Plaines Wilhems—area 70 square miles	...	1 I Class Ranger. 1 III do. 5 IV do. 1 Curatelle Keeper.
Total	...	8
District of Grand Port—area 112 square miles	...	1 II Class Ranger. 5 IV do.
Total	...	6
District of Savanne—area 92 square miles	...	1 III Class Ranger. 1 IV do.
Total	...	2

District of Flacq—area 113 square miles	...	1 III Class Ranger. 3 IV do. 1 *Keeper of Crown lands.*
Total	...	5
Districts of Pamplemousses and Rivière du Rempart—area 145 square miles	...	1 III Class Ranger. 2 IV do.
Total	...	3
District of Black River—area 95 square miles	...	1 III Class Ranger. 1 IV do. 1 Curatelle Keeper.
Total	...	3

The duties of *this* Force *consist* merely *in guarding* Crown lands, and protecting Mountain and River Reserves; arresting and prosecuting offenders; and enforcing generally the provisions of Ordinances No. 18 of 1874 and No. 13 of 1875. In fact, their duties are strictly those of Police.

The Forest Laws of Mauritius, however, legalise the same *and similar* duties being performed by the regular Police Force of the Colony. Under those circumstances, therefore, it would appear that the present Forest Ranger Staff is not only ample, but almost superfluous.

There is, however, some misunderstanding on the subject, the result of which is that the forest protective duties have been withdrawn from the Police, and which would appear to be *contrary to the direct provisions of the law. Nevertheless* it is obvious that a considerable part of the duties, now performed by the Forest Staff, could easily be performed, and with great advantage, by the existing Police Force; such as the protection of River and Mountain Reserves and the "Pas Géométriques," which the law directs shall be protected, and permanently maintained in wood, and which would practically amount to nothing more than the protection of public property, for which the Police Force is the constituted guardian.

Were the misunderstanding, which has been alluded to, removed, it would have the effect of releasing the Forest Rangers from some considerable part of their present duties; and which would enable them then to attend to the more legitimate work *lying within the Crown forests and plantations of* the Colony. In fact, so little have these men to do with such duties that the Forest Officer from India, who was sent for to inspect and report on the forests of the Island, in frequently asking their aid to be shown over the forests, was repeatedly met by the plea of inability to do so, owing to the Forest Rangers being engaged in prosecuting offenders against forest laws, lying outside of their legitimate jurisdictions. And not

only was this so, as regards the Protective Forest Establishments, but particularly so as regarded the officer who is styled the Guardian of Woods and Forests, and who is the head of the Forest Protective Staff, that in no one instance was that officer able to accompany the Forest Officer from India in his tours of inspection of the forests of the Colony.

Class of Forests.

In Mauritius we find three distinct classes of forest property, which may be defined as follows :—

I.—The "Pas Géométriques" and River and Mountain Reserves.

II.—Ordinary forests, the property of the Crown.

III.—Forests, the property of private owners.

Class I.
Pas Géométriques, Rivers and Mountain Reserves.

In the case of this class the law of Mauritius is the originator and protector of these properties for the public good; and they are the only forest properties which the law requires shall be maintained permanently under the growth of trees, quite irrespective of whether the land belongs to private individuals or to the Government.

Pas Géométriques.

The Pas Géométriques is a strip of land, 250 French feet in width, laying along the extreme edge of the Coast all round the Island. River Reserves are strips of land, more or less covered with trees, bordering on each side rivers, streams and rivulets, for the preservation of the water-supply in them. The strip may be 50, 25 or 10 feet in width respectively, on each side measured from the water's edge; and Mountain Reserves are constituted for the preservation of forest and tree growth, along the crests and sides of mountains, their spurs and isolated hills.

Mountain Reserves.

The history of the law, requiring the maintenance, and giving protection to these several properties, dates from the French occupation of the Island. It would appear that, under the former *regime*, this law was interpreted more strictly; but as time went on, and population began to press onwards from all sides, its provisions were relaxed, insomuch that, at the present day, what were formerly considered as Mountain Reserves are now no longer such but in name. Under the provisions of Ordinance No. 13 of 1875 considerable alterations were made during the codification of all previous Laws, Arrêtés, Proclamations, Notices and Ordinances on the subject. These alterations would appear not to have been judicious, at least in that respect only, as regarded what should constitute Mountain Reserves and rules for their preservation; inasmuch as existing Mountain Reserves,—since the passing of this Ordinance, and which originally meant the protection of the woods and forests, covering the mountains—are represented at the present day by, in most cases, a mere ribbon of thinned-out forest growth along their crests; their sides and bases having been cleared away and

brought under cultivation. In some cases, the imaginary lines constituting the Reserve Lines of the Code, pass over and above the mountains and their spurs—hence no Reserves are possible under such circumstances. A study of the new law, and its interpretation of what constitute Mountain Reserve Lines on the ground, will however make this subject clear to any one desirous of making the experiment. This subject has already been brought to the notice of His Excellency the Governor by personal communication.

River Reserves.

As regards River Reserves, they have been better managed, especially in the more populous districts. The law requiring that a belt of trees, bordering the rivers and streams, be maintained by the owner of the land, be that owner the Crown or a private individual.

This, like what the Mountain Reserves were intended to be, but are not, is a wise provision of the Legislature. It only requires, at the present day, to be more strictly enforced in all parts of the Colony; and were it thus strictly carried out, and the width of the belt, of protecting trees, always maintained at 50, 25 and 10 feet respectively as the law directs, not measured from the waters' edge, but from the top of the escarpment inland, a very considerable increase to the present water-supply would result; besides, these belts of trees would act as screens, to protect the sugarcane plantations against the violent action of the prevailing winds.

An examination of the Map of the Island will show that were the law relating to Mountain and River Reserves modified in accordance with the views herein expressed, a considerable space of the land would be covered and perpetually maintained with forest and tree growth, to the manifest and ultimate benefit of the health, water-supply and conveniences of the people of the Colony.

Ordinary Class II. *Forests, the property of the Crown.*

These consist of forests of spontaneous growth, and plantations of woods artificially created.

A considerable portion of the Crown lands is occupied by Mountain and River Reserves, and forests covering extremely shallow and rocky soils, in which position they are not available for yielding any appreciable outturn in timber or other marketable commodities.

The situation of these lands may be indicated as follows: In the south of the Island, but on the table land, lies a group known as the Grand Bassin Block; another group lies in the centre of the Island, and is called the Piton du Milieu Block; a third group occupying the mountains, spurs and gorges of the Black River District; a fourth group occupying the greater portions of the higher and elevated parts of the Port Louis Range; and the fifth stretching along the mountains, with

some outlying tracts, known as the Grand Port and Flacq Range. Included within these principal groups are, of course, the several outlying small plots of land likewise owned by the Crown, several of which have been brought under plantations of young wood by artificial means. Again a few of these isolated tracts have been leased out to cultivators, and one large block, known as Reduit Domain, on which stands Government House.

With the exception of the Blocks, known as Grand Bassin and Piton du Milieu, there are no other forests worthy of the name. Both these Blocks measure in the aggregate about 8,420 arpents; but after deducting 2,410 arpents of extremely shallow and rocky soil, the total of what may be considered as good forest soil, under spontaneous growth, does not amount to more than 6,010 arpents, although the total area of determined and undetermined Crown lands amounts to 34,342 arpents (or 35,750 acres). As said before, these Crown lands in a great measure constitute what are called Mountain and River Reserves, besides great tracts which lie in the lower parts of the Black River District and which have been entirely denuded of all forest growth.

Viewed as a whole, the Crown forests of the Colony of indigenous growth, whether classed as ordinary forests or Mountain and River Reserves, present a picture, with some slight exceptions, of doleful ruin. From most or all of them the valuable kinds of timber-yielding trees have been cut down and removed. What now remain are the dead, the dying and diseased trees, of mature and immature growth, of the less valuable species, the timber of which was not worth the trouble of felling or the cost of carrying away. These trees, left by former wood-cutters, have since been damaged by hurricanes, which they were unable to resist, owing to the original forest growth having been thinned out in the course of extraction of the more valuable woods; the sudden exposure thus caused to sun light, and to the swaying of the trees by the constant strong winds that blow during the greater part of the year, combined with the attacks of xylophagous insects, have completed the ruin of what at one time were no doubt the noble primeval forests of Mauritius.

With a few exceptional but small tracts lying in the mountains and therefore inaccessible to the wood-cutters, there remains not now a single forest of indigenous growth, containing marketable timber of fair value, in the possession of the Crown. Recently were purchased some forests, which now form a part of the Grand Bassin Block, and which still contain (about 800 arpents) of the untouched growth of centuries, but which are mainly composed of species yielding timber of little value. In these forests, trees of *Canarium Colophania* (the Colophane) and of *Sideroxylon grandiflorum* (the Tambala-

coque) attain a height of 50 feet with a girth of from 12, 14, 16 and 19 feet respectively. Trees of this size are rare, standing on an average about one tree to the acre, but the general forest growth is nevertheless dense and impenetrable, except by paths cut through it; and its average height rarely exceeds 30 feet. These, as well as all existing smaller tracts of forests composed of indigenous species, are evergreen, and are thoroughly tropical as regards their composition and character.

Plantations.

These consist of two classes, namely, forest plantations and plantations created for sanitary purposes. Of the former, there are but four, *viz.*, Powder Mills, Trou aux Cerfs, Terrain Quessy, and Concession Dayot. Of the latter, there are several situated near and around Port Louis; Marsh land at Mon Plaisir; Foreshores of Grand Bay; Foreshores of Poudre-d'Or; Mahebourg; Quarantine Stations and Road Sides—all more or less planted with Filaos (*Casuarina equisetifolia*) as nurses, with the more valuable foreign and indigenous trees intermixed. There are, however, two exceptions to this mélange, *viz.*, Concession Dayot and Terrain Quessy, which are natural forests restocked with the more valuable indigenous forest trees intermixed with a few foreign broad-leafed species. It is not practicable to state what the combined areas of all the above plantations amount to, as the data for this calculation are not available, except in a few instances, which will be given shortly.

Forests Class III. the property of private owners.

These, like the Crown forests, are in a state of utter dilapidation. The only forests worth anything at the present day are those belonging to the Honorable Mr. Pitot, situated in the south of the Savanne District, and measuring some 2,000 arpents; and a considerable forest, though not uncut, lying near the Quartier Militaire in the Moka District. The extent of this forest is 4,171 arpents; with these two exceptions the private forests of Mauritius may be said to have been worked out of all valuable timber. It is estimated that, including the above 6,171 arpents, there are not, at the present day, 16,000 arpents of private forests which contain trees of large size, and that at the most 10,000 arpents contain nothing but the dead, the dying and diseased trees of mature and immature growths of inferior species; and that even these are fast, *daily*, disappearing beneath the axe of the wood-cutter and sugar-planter combined.

There are, however, extensive stretches of small growth coming up all over the Island, wherever sugar plantations have been abandoned, or where the heavy timber has been cleared off. Probably there are 50,000 arpents, and more, of such lands available at the present day; all, more or less, covered

with a luxuriant young growth of subspontaneous species—many of these species, of course, are worthless, except as fire-wood—and with a few straggling representatives of the native trees among them in the higher parts of the Island, and which will ultimately grow up into fine timber trees if spared long enough. This secondary but spontaneous growth—a remarkable and hopeful feature in the present state of matters—which is coming up all over the Island, with a few exceptions to be noticed hereafter, if protected from injury and allowed to grow, in 20 years would reforest the Island without a cent being spent on planting.

Of course such growth would not form valuable forests in the sense of timber yield; but for shading the ground, preserving the water-supply, and providing fuel and small building material for the people, it would serve admirably. It would, with the existing Crown lands, Mountain and River Reserves, and the existing private forests, if these could be now saved from further destruction, aggregate upwards of 100,000 acres or thereabouts under wood, or nearly 25 per cent. of the total area of Mauritius, of which only a little more than one-fourth is at present under sugarcane cultivation.

Private forest plantations.

The Crown alone has not created artificial plantations of young woods. A number of small private plantations of *Casuarina equisetifolia* or the "Filaos" are dotted about in various parts of the Island, forming most picturesque groups of trees in the general landscape of the country. At *Mon Désert,* in the Grand Port District, there is a plantation of over one thousand one hundred acres, and which is supposed to contain two millions of trees valued at one dollar (or 2 rupees) each! All these plantations are in flourishing condition, and are remarkably fine, showing clearly how easy it is for landed proprietors, especially those who can afford the initial outlay, to place under wood such portions of their estates as are not otherwise utilized in the cultivation of the sugarcane. As regards the tree "Filao," there should be no prejudice against its extensive cultivation in the lower parts of the Island, where the rainfall is moderate, but where the moisture-laden sea breezes cause it to flourish and attain large dimensions, and where few of the better quality of timber yielding indigenous trees thrive. The "Filaos" should, as a rule, be planted somewhat thickly, and allowed to attain a height of 25 feet before being thinned, and then only the overtopped trees should be taken out; so that the upper, or crown foliage of the remaining trees, continue to retain and form a thick covering overhead. The introduction of some of the smaller shade-loving shrubs, so plentiful in Mauritius, to cover the ground under the trees, would be an advantage, and therefore ought never to be neglected when laying out new plantations.

Having reviewed in a general way the Forest laws, Forest establishments, the classes into which Forest properties are divided, and given a general sketch of the latter as they exist at the present day, we will now proceed with more detailed descriptions of the Crown forests and Crown lands of the Colony, and offer suggestions for their future management.

Area of Crown lands including that of "Pas Géométriques" and some plantations.

We will open with the remark that the areas here given of the Crown properties have been derived from information supplied to us by the Surveyor-General of Mauritius, and are based by him in some cases on actual measurements, and in others on estimates only where the land has not yet been surveyed. We are therefore in no way responsible for the correctness or otherwise of the figures now produced.

The total area of the Crown lands is said to be as follows :—

Determined, *i.e.*, measured	21,123 arpents
Undetermined, *i.e.*, not measured, but estimated	13,219 „
Total...	34,342 arpents,

which is equivalent to about 35,750 English acres—the French *arpent* containing 208 square yards more than an English acre, which is of 4,840 square yards.

It would certainly have been more satisfactory to have known the exact quantity of land which the Crown possessed in the Colony, but such information is not available in the Department of the Surveyor-General.

The Map, which has also been supplied by the Surveyor-General on the requisition of the Colonial Secretary, shows the distribution of the Crown lands. From it it will be observed that a considerable part of these lands (7,500 arpents) is occupied by what is known as the "Pas Géométriques." Another large portion (9,452 arpents), a considerable part of which is still undetermined, lies in the mountains and gorges of the Black River District. These lands at one time contained valuable forests, all of which however have been long since cut down and removed, and are now spontaneously replaced by forests of secondary growth, composed of introduced non-indigenous species. Another belt (4,859 arpents), the greater part of which is also still undetermined, stretches along the mountains known as the Grand Port and Flacq Range; while in the north-west, covering to some extent the spurs and ridges of the Port Louis Mountains, are belts of forest carrying lands (3,931 arpents).

In the south of the Island, and having an elevation of 1,400 to 2,300 feet above sea level, lie the group of Government forests (5,801 arpents), the greater part of which were purchased recently, known as the Grand Bassin Block

And in the centre of the Island, constituting a single block (2,798 arpents) lie the forests of Piton du Milieu.

Divisions and Area.

We may therefore divide, including outlying neighbouring plots, the Crown forests and Crown lands into six principal divisions or groups, as follows :—

I.—" Pas Géométriques," estimated area ...	7,500	arpents.
II.—Gorges and mountains of Black River District	9,452	"
III.—Grand Bassin Block...	5,801·5	"
IV.—Mountain Range of Grand Port and Flacq	4,859·5	"
V.—Piton du Milieu...	2,798·5	"
VI.—Mountain Range of Port Louis	3,931·	"
Total ...	34,342·5	arpents.

The Map, in which the Crown lands which have been determined are tinted yellow, and those still undetermined brown, show how very scattered these lands are. It is quite obvious that with outlying plots the difficulties of protection are considerably increased, besides rendering it more costly.

1. Pas Géométriques. Situation and extent.

The "*Pas Géométriques*" is a strip of land, which is maintained by law, marching with the coast all round the Island. In some places the continuity of this strip is broken, owing to private rights intervening. In others again the strip is considerably widened, due to lands lying alongside being the property of Government. In the greater portion the exact limits of the "*Pas Géométriques*" has been determined, but there still remain considerable portions of it, and the adjoining lands, which have not yet been defined or settled; and which, in some instances, are still in the hands of private persons.

Present condition of growth.

It has already been stated the law compels that the "Pas Géométriques" shall be planted with trees, either at the expense of the Crown by the Surveyor-General, or by lessees who may lease the land; the latter on condition that one-fifth of it be planted up yearly, and one-tenth of the trees be realized annually, after the growth of twenty years; and, also, provided that lessees immediately replant the land from which the trees were removed. Failing in any one of these conditions are heavy penalties attached.

At the present time, however, the whole of the "Pas Géométriques" *is not* under trees, though a very considerable portion of the land has been planted up, both by the Crown and by private persons. The tree selected for this purpose is the "Filao" (*Casuarina equisetifolia.*) Many of these plantations

are in a very flourishing condition, the trees growing remarkably well and vigorously. In time they will form, when the whole of the land has been planted up, a magnificent living, flourishing evergreen belt of tree vegetation all round the Coast; and which no doubt, shortly hereafter, when thinnings are made, will furnish a considerable supply of building material and fuel.

Future management.

This will consist, at least for the present, in planting up all the available ground as vigorously as funds at the disposal of the Government will admit. The work should be begun and carried through in a systematic manner, and not spasmodically, as appears to have been somewhat the case. There is nothing easier than to lay out, at the beginning, a systematic plan of work, and then to carry it out fully. The plantations should he laid out in lines six feet apart, and the young trees planted at distances three feet apart in the lines. This will give 2,420 trees to the acre, not too much for a species like the Filao, which will attain the height of 25 feet when so spaced out without requiring to be thinned. However it is not intended that all the future plantations should consist of only one species. On the contrary, the Filao must be looked upon in a great measure merely acting as nurses to the more valuable kinds. The following are recommended for seaside planting, and for stocking permanently the Pas Géométriques and contiguous lands. It is of importance that a selection should be made of such trees as will give a return in yield of fruits, the right to collect and sell which may be leased out annually :—(1) *Mango*, (2) *Jack*, (3) *Tamarind*, (4) *Bread-fruit*, (5) *Litchi*, and other fruit-bearing shade and shelter-yielding trees. The plantations of such trees should be laid out at sufficient distances apart, tree from tree, as will not necessitate the removal of any, when the Filaos, which have acted as nurses, will have all been cut out. The cost of planting and any necessary guarding during the earlier stages of the plantation will be fully repaid by the value of the Filao poles and firewood produced.

Thinning and lopping.

These should never be undertaken hastily. It is one of the faults of existing management that thinning, with the view of improvement and making money, is attempted too soon and carried out too vigorously for the health and future stability of the remaining trees. As a rule, no thinning ought to be attempted so long as the young trees, overtopped, do not show signs of utter suppression, when the *latter only* ought to be taken out, and *no others*. What should be chiefly looked to, is the maintenance of constant shade over the soil of the plantation by the remaining growing trees, whose crowns of folinge should touch one another, without being swayed by the winds. Nothing but

compact masses of growth can resist the hurricanes; and no forests can be said to be in healthy, vigorous growth, unless the canopy of foliage above is sufficiently compact to obstruct the direct rays of sun-light from reaching the soil below.

Moreover, lopping or pruning should not be attempted in plantations of forest trees; it is not required, and it is not possible, unless the trees originally stand so far apart that they can develop large side branches; or which can only be, when thinning out heavily, at an early stage of growth, is practised.

Powder Mills Plantation.

The remarks, contained in the foregoing paragraph apply with considerable force to the present management of these plantations. These plantations, of mixed Indian and other foreign species, were commenced in 1870, and are now therefore of 10 years' growth. They comprise an area of 180 arpents situated in the Pamplemousses District. The growth of the trees has been remarkably rapid, and in good form and shape, but the plantation has been much injured by severe thinnings and loppings of the larger branches.

Amongst the Indian trees are *Teak*, *Pterocarpus Marsupium*, *Terminalia Arjuna*, *Albizzia procera*, which have attained a height of thirty feet, also *Dalbergia latifolia* and *Sissoo*, both of which promise well for the future; *Cassia florida*, *Berrya Ammonilla*, *Bassia longifolia*, *Pterocarpus santalinus* and *indicus*, all of which are growing fairly well.

It is believed that already a considerable revenue has been derived from the sale of thinnings and prunings against the cost of the plantation, which, up to end of last year, amounted to Rs. 8,886, or nearly Rs. 50 per acre. Nothing could be finer or more flourishing than this plantation, but which unfortunately, at the outset, has met with some severe treatment, but which it will, no doubt, get over if future hurricanes do not knock it about too severely.

Future management.

At present the very best treatment this plantation could receive would be, to let it alone for a few years, and not to attempt to remove any trees except those—and a very few there can possibly be—which have been overtopped, and whose chance of making a start again is now entirely lost. Where blanks exist, these should be planted up with fast-growing species, of two and three years old stock, that can bear transplanting well; so that they might catch up the existing growths and thus form a compact forest. No cleaning is required, nor is it at all necessary when the young trees have outgrown weeds, &c., but creepers, which twine round the stems of the young trees, should be killed.

The foregoing remarks are not offered in any disparagement of the good work done by the two Directors of the Royal Botanical Gardens (Messrs. Horne and Cantley); on the con-

trary, what these officers have done for the Colony in the way of getting up successful plantations of trees will be a lasting credit to their management. The remarks are merely meant to indicate what ought to be avoided in future; as much *depends on the present treatment the plantations receive*, whether they will become healthy remunerative forests in the future. Present revenue must not be looked for; and on no account should it be insisted upon.

Other plantations.

There are, besides the Powder Mills, several other plantations in the lower parts of the Island, near and about Port Louis and elsewhere; but as they are all in excellent condition, and bear every promise for the future, we shall leave them with these brief remarks. Thoroughly trained horticulturists as the Directors are, they *do not require any teaching in their own special branch.*

Future management.

They must however not thin their plantations, except by the removal of already overtopped trees. Lopping will not be necessary then; and every endeavour should be made to maintain a dense undergrowth, *beneath* the young trees, as dense as they can possibly create it, and which is quite possible with the numberless shade-loving species which abound in Mauritius. It will be then, only with perfect cover overhead, and immediately in contact with the soil, that the forest growth will not *only be vigorous, but the soil, which is physically* of a porous nature, will be kept perpetually moist when shaded from the sun, and screened from the drying action of the winds. In most of the Filao plantations in the Colony, there is absolutely no cover beneath the young trees, and it has been said that nothing will grow there. This, it is certain, is generally not the case; for wherever undergrowth has been allowed to come up, it has flourished and screened the soil from the drying effects of the winds, and increased the vigour of the Filaos thereby.

2.—Gorges and Mountains of Black River District. Situation, extent and present condition.

The *estimated area of the gorges* and *mountains* of Black River is 9,452 arpents. The forests are situated at various elevations between 400 to 2,000 feet above sea level, on the steep slopes and valleys of the gorges of the Black River, with a fringe of wood running along the brow on the edge of the plateau above. The valuable trees have all, long since, been worked out. A few trees of first class size, *i.e.*, of over 6 feet in girth, are met with, situated on ledges overhanging rocky precipices, and which in such *situations are not available to the wood-cutter*. The belt of worked out forest on the brow of the plateau still consists of a few fine Nattes (*Imbricaria maxima*), the most valued of all timber yielding trees; but the majority of the trees composing this belt consist of the less valuable species in a greater or lesser

stage of decay. A young and vigorous growth, however, is rapidly filling up the forest, composed chiefly of such species as the Natte, the Makak (*Imbricaria petiolaris*), several of the more useful Pomes (*Eugenia*) and Ebony. It is remarkable the way in which this young growth has shot up, after the former forests were cleared away, and what is still more remarkable is, that the young forest is not coppice regrowth, but sprung direct from the seed.

Wherever this young growth exists, it is perfect as regards proportions in which the more valuable species are mixed, and their distribution over the ground. No artificial plantation could ever compete with this natural regrowth, which has appeared, after the mature forests had been removed. The cutting of the old forests in these localities was evidently that of clear cutting, for apparently everything was removed off the ground either in the shape of timber or of fuel. As instances of which and the young growth alluded to, the tracts of forest land known as Terrain Quessy, both private and Crown property, may be indicated.

However, it is only on the brow of the table land that this has occurred. The great mass of the forest on the steep slopes of the mountains, and filling the valleys, are, however, composed of mostly inferior introduced species, which have taken up and occupied the ground after the indigenous trees had been removed. These subspontaneous species now form perfect, compact, well grown forests in most parts of the gorges, comprised of such species as *Tetranthera laurifolia* and *monopetala*, *Albizzia Lebbek*, *Tamarinds*, *Guavas*, *&c.*, intermixed here and there, but much more so at the higher elevations, with some of the indigenous species of the Island.

One-half of the area of this group of forest land is, however, very nearly bare of all forest growth. The range known as the Tamarind Mountain, and the land lying along the left bank of the Black River just opposite, are instances.

Future management.

From their situation the majority of these forests are of not much immediate value; but since a great part of the soil is still capable of being, under good management, brought to bear healthy forests, it may as well be to show how this is possible under existing circumstances.

Forests on table land: their treatment.

Beginning on the table land, it will be necessary to remove all dead, dying and decaying trees, and sparing all those that are still healthy and capable of producing and shedding seed. Owing to the heavy rainfall in this locality, about 160 inches per annum, it would perhaps be best to make a clear cutting of all such trees that have attained maturity; and where reproduction has naturally not been complete or full, assist it by plainting from nursery stock not younger than three year old.

Younger plants will not do, as they will get grown over, and will constantly be cut back by the deer. It will be necessary to establish seed beds and nurseries on the spot to save carriage and risk to the young plants of removal over long distances. With this view extensive collections of seeds of the "Natte," "Makak," "Bois de fer," "Bois Sandal," "Tatamaka" and of other valuable indigenous species should be made, and sown as quickly as possible. No young seedlings should be dug up in the natural forests and brought to nurseries, but seedlings should be raised in seed sown beds. Watering will not be necessary, but the seedlings should be transplanted once or twice in the nurseries to cause them to develop more fibrous roots. In restocking natural forest growth, it will be sufficient to put the plants in where they are required by the existing blanks, or where a more perfect intermixture of good timber-yielding species is desired. They may, likewise, be put out in lines, cleared six feet wide, in a single row at four feet apart between plants. This only when the spaces, taken up by the cleared lines, are already occupied by species it is not desirable to retain. Otherwise it would be well, where the intermixture of good species is tolerably fair, as at Terrain Quessy, only to fill up blanks, and leave the remainder as it stands. No thinning or pruning should be attempted. It will be sufficient if the Forester in charge see that no valuable species are being overtopped and thereby suppressed by their inferior neighbours; and it will be his duty to cut back any inferior species thus gaining ground over the more valuable kinds. But it must always, however, be remembered that we are dealing here with evergreen tropical forests, of which there are rarely few species composing them, that cannot stand shade, and which are not permanently injured by isolation and exposure.

Camphor and other foreign trees.

Camphor trees (*Cinnamomum Camphora*) have been tried at Terrain Quessy, and with some success. Perhaps a few may still be introduced in the artificial melange, but it is not recommended as it is not a valuable timber-yielding tree; and many of the indigenous trees are of still greater value in their ultimate yield and the shade which they throw on the ground. These properties ought not to be overlooked—it being, also, remembered that the indigenous trees stand out the hurricanes best, for which they are specially suited. They have been tried and found to resist them, whereas many of the foreign species, although rapid growers, have yet to be tested in this respect; when raised in masses, probably thus, they will withstand the hurricanes, but the experiment is still untried. Great caution is therefore necessary in recommending, where large and expensive plantations are concerned, what species to select from among the numerous foreign kinds that will undoubtedly grow

with much vigour and rapidity in the soil and climate of Mauritius; but as to what their ultimate fate will be, with disease, hurricanes and a generally shallow soil, is harder still to predict. However, a list of the most likely species, and which may be tried tentatively, is appended to this Report.

Forest on steep mountain slopes.

The treatmeat of the forests, occupying the steep slopes of the mountains, is to leave them as at present guarded and protected from destruction. The slopes are much too steep for any regular cultivation. In time the more valuable indigenous species will creep in and probably suppress the present almost valueless growths. Their power to stand shade, during the earlier stages of growth, give the indigenous species a considerable advantage over their foreign rivals, who will no doubt *begin to disappear as soon as they find themselves overtopped.* However, as these forests stand at the present day, they do much good by clothing the steep sides and slopes of the mountains, and by shading the ravines which drain off the waters from them.

Sheltered valleys may be planted with foreign trees.

As regards the valleys, where the soil is tolerably deep and somewhat rich, plantations of Eucalypts, Auricarias, Mahogany and the Toon (*Cedrela Toona*) may be tried with advantage. These valleys are sheltered, and probably therefore the plantations would in such situations escape the more destructive effects of the hurricanes. In some of the higher valleys, the Eucalypts and Araucarias will find a congenial home, while the lower parts will suit the Toon and Mahogany best. The Toon might most decidedly be largely introduced into the Colony, and planted in along the bottoms of the deep ravines which score the surface of the Island. In such localities the tree would escape the full force of the hurricanes. It grows remarkably well, as far as tried, in the soil and climate of Mauritius; and its timber will be extremely valuable for furniture and constructive purposes. It besides yields a dense shade.

Treatment of open and bare lands.

The treatment which the open bare lands of Mountain Tamarind, the bare strip along the left bank of the Black River and *Morne Brabant* will require, will be somewhat as follows:—

Method of treatment.

I.—It will be necessary to plant up, with one-year old seedlings of *Terminalia tomentosa* and *Arjuna*, the wet black soil, the plants being placed out in lines five feet apart, and three feet apart within the lines. The seed to be obtained from India. Mixed with the *Terminalias* should be *Eugenia Jambolana*, in the proportion of one in ten of the other. The spaces between lines should be sown in plots, 12 × 12 inches, with the seeds of various evergreen shrubs common to the Island. The seeds of *Tetranthera laurifolia* should also be plentifully gathered, and sown in plots, in all the drier parts outside of the black

wet soil. The plots should be prepared by digging down nine inches deep and removing the larger stones from the soil; they should be arranged in lines parallel with the planted lines. All original growth, at present on the ground, should be strictly preserved, even where it falls within the lines of plots or plants. Sowing and planting should be commenced early in the beginning of the north-west monsoons, and should never, on any account, be carried farther into them than one month after they have commenced: this will then give the transplants and germinating seedlings the benefit of all subsequent showers, which will help considerably to establish them before the setting in of the dry weather. All preliminary operations, such as digging the pits for the plants and preparing the plots for seed sowing, should therefore be carried out before the monsoon rains begin, which will probably be by or about 1st December.

Method of treating Mountain Tamarind.

II.—The steep slopes of the Tamarind Mountain should be sown with a mixture of seed, such as that of *Tetranthera laurifolia, Albizzia Lebbek* and *procera, Dalbergia latifolia, Bassia longifolia, Pterocarpus Marsupium, Acacia leucocephala* (if that is not already established there), *Adenanthera pavonina*, and such of the indigenous evergreens growing usually at such altitudes. The seeds should be sown in horizontal contouring beds, the continuity of which must be broken wherever natural growths, now occupying the sides of the mountain, are met with. These beds need not be more than two feet wide, the soil well worked up in them, and the stones extracted and laid along the *outer* edge; the beds must slope inwards slightly to keep the soil from being washed away by the rain, and the seed sown over the whole surface of the beds. Before sowing, the seeds should be thoroughly mixed up together, the heavier and larger, and the smaller and lighter, seeds all together. A *very slight* covering of soil is all that will be necessary to put over the seeds. The distance between consecutive beds will be regulated by the slope of the mountain, and may be, according to it, 10, 15, or 20 feet. Inspection paths must be laid out at the time the beds are being prepared; these paths need not be more than three feet wide, with a slope of 1 in 30 or 35. In fact such paths—a fine example of which may be seen leading to the bottom of the *Trou aux Cerfs*, built by Mr. Lavignac, who lives down there. In fact all mountain forests ought to be provided with similar inspection paths, which can be constructed at little expense, and which could always be kept in thorough repair by the Forest Rangers.

Method of treatment for Morne Brabant.

III.—As regards *Morne Brabant*, it will probably be best to plant it with *Filaos*, unless there is considerable rock underneath the surface soil, when perhaps the best way of getting it under tree vegetation will be by sowings

carried out in a manner similar to that suggested in the case of Tamarind Mountain.

Under a combined system of sowing seeds in horizontal bands and plots, and planting out in pits young trees previously raised in nurseries, any of the now bare bleak hills in the Island may be successfully reclothed with tree vegetation. As a fact a considerable young growth, but scattered about in patches, even now covers the bleakest hill sides. What is chiefly required for it is protection, and the blanks filled up artificially, the probable cost of which will not exceed Rs. 20 per acre, where sowing alone is carried out; but under a composite system, namely, that of sowing and planting, the cost will be raised to about Rs. 30 per acre. This would include the collection of the seed, raising young plants in nurseries, preparing the soil, planting and sowing the seed—the price of labour being the only heavy item all through. It must, however, be distinctly understood that artificial watering of the plantations is neither anticipated nor allowed a place in the above estimates, except for raising the young plants in nurseries in the first instance. If the sowing and planting be carried out and completed as suggested, during the first month of the monsoon weather, no after watering will be necessary. This is an important point, and should not be overlooked. It will otherwise make all the difference, not only in the success of the operations, but also in their ultimate cost.

Probable cost per acre of combined planting and sowing.

Having planted the land and sown the seeds, all that will be necessary will be to watch the growth, and prevent the seedlings and young plants from being choked by the grass and creepers, which are certain to appear in the plantations. One or two weedings at intervals of six months, with cultivation of the soil around the young trees and seedlings, will be necessary for a year or two, according to the progress they make; after which they ought to be left to themselves to make their own way up. The ultimate cost of an acre of plantation will then stand somewhat as follows :—

Treatment during second and third years.

First year under composite system	... Rs.	30
Second and third years' weeding and cultivation	,,	6
Or, Total ...	Rs.	36 per acre.

If planting alone be carried out, the cost of it, according to what similar plantations have already cost in Mauritius, which cost has much depended on the time and age that transplants were put out at, will be between Rs. 40 and Rs. 45 per acre, exclusive of superintendence; or, say, at an average of Rs. 50 per acre all round up to the period the plantations are fairly

established. It is quite practicable, however, under a well designed scheme, carried out with thrift and economy and on a large scale, to lay out plantations of young trees in Mauritius at a cost not exceeding Rs. 40 per acre. For less it could probably not be done in a satisfactory manner, in a place where the price of labour is double that of some and treble that of other parts of India.

3.—Grand Bassin Block. Situation, extent, and present condition.

Grand Bassin Block.—Estimated area 5,801·5 arpents. The forests composing this Block are situated at elevations varying from 2,300 to 1,400 feet above sea level. The principal mass of them, however, lie at a medium elevation of 1,900 feet, within the region of maximum annual rainfall which exceeds 140 inches; and they likewise occupy the central southern parts of the table land. Each forest composing the Block is clearly demarcated with stone boundary pillars, marked with the broad arrow, and bearing numbers corresponding to the series in which they stand. The boundary lines are straight and well kept up, being always open, and maintained so by the Forest Rangers in local charge. A complete and comprehensive map, on the scale of 1,000 feet to the inch, has been prepared of these forests by the Surveyor-General, under whose orders the above very satisfactory preliminary works have been carried out. Protection to the forests is also perfect; the Forest Rangers in charge, and who reside in the forests, being men of some intelligence. One man especially, Lebreton by name, is one of the best Forest Rangers of the force, and knows his work, and the local names of the various trees which compose the forests extremely well.

In one of the forests, Concession Dayot, there is also a nice comfortable house which was built by Mr. Horne, Director of the Forests, who lived in it at the time the forests were being worked for the extraction of the dead, dying and diseased trees, which still however to a great extent predominate, and which will have to be removed for reasons which will be shown hereafter in the proper place.

Forests of Les Marres and Mountain Cocott.

The forest known as "Les Marres," 2,039 arpents in area, and that called Mountain Cocott, 371 arpents in area, are situated on extremely wet and rocky soils; and the forest growth, in consequence, is composed of inferior species of short growth. The Les Marres are extensive marshes, near and around which are chiefly found the "Manglier" (*Sideroxylon Bojerianum*, and its varieties) a worthless tree. On the whole there is nothing of much value in these forests, but they must nevertheless be protected, as from their position they give rise to, and preserves numerous springs which go to feed the rivers flowing towards Savanne and the Black River District.

Other Forests.

Of the remaining forest lands, one containing 188, and another containing 667 arpents, are not now under heavy wood; but carry a small young growth of various species. The forests of Dayot, Talbot and of Mare Souilliers were purchased recently by the Crown, and for which was paid some Rs. 650,000—the combined area of these forests being some 2,545 arpents. The Mare Souilliers, as its name denotes, is a marsh of considerable extent covered with a worthless forest; the "Manglier" being the prevailing tree. In lower and drier parts the forests are however better, composed of more valuable species, and the growth finer. Parts of Talbot and Dayot, however, contain the best grown Government forests in the Island at the present day; but in which unfortunately are but very few trees, the timber of which is at all valued in the market. In truth these forests owe their present existence to this fact alone. However such species as Tambalacoque (*Sideroxylon grandiflorum*), Colophane (*Canarium Colophania*), Bois d'Olive, (*Elæodendron orientale*), Makak, (*Imbricaria petiolaris*), Natte (*Imbricaria maxima*), Bois de Fer (*Stadtmannia Sideroxylon*), Tatamakka (*Calophyllum inophyllum*), some of the larger Eugenias called "Pomes," and a large timber tree not yet botanically identified, called locally Bois de Sandal, may be met with; none being common, rather on the contrary the best specimens occur in the more difficult ground. It is only in these forests that an idea can be gained of the grandeur and composition of what are essentially known as Evergreen Tropical Forests, and which at one period must have covered, with the densest tree vegetation it is possible to imagine, four-fifths of the area of the Island. The tree-ferns rising to heights of 25 to 30 feet, the countless other Ferns, the Peppers, Creepers and Twiners, the mass of tall clean-stemmed undergrowth, packed so closely together as not to give passage to a man through them, and above all the dense, almost black, shade of these forests, are something to see and to admire. The average height attained by the forest growth is not over *thirty feet*, but individual trees are not wanting which tower above the mass to a height of fifty to sixty feet, and support, in the forks of their branches, those ferns and orchids which love the light. It is in these huge excrescences formed by these plants growing together in masses that the "Paille en queue," or Boatswain or Tropic Bird, the *Phæton candidus* of ornithologists, loves to breed.

Future treatment.

As a great part of the forests comprised in this Block are in bad condition, owing to the extensive and injudicious fellings which were carried on in them before they fell into the hands of Government, it will be necessary to restock such portions artificially on which the young growth, now on the ground, is deficient. To do this properly, and to remove the large quantity of dead and dying

trees that abound everywhere, it will be necessary to carry out works similar to those introduced about three years ago in Concession Dayot.

All dead, dying and diseased trees should be removed—great care, however, being taken that the sound and healthy trees are left on the ground.

A plentiful supply of young healthy seedlings of the more valuable indigenous species should be provided in advance of these operations, in order that the restocking of the forest may proceed with the extraction of the old trees. It would be advisable to try here a mixture, with the indigenous species, of the Indian Pine known as *Pinus longifolia*, which at Curepipe has a remarkably vigorous growth. Likewise also *Pinus Kasya* and *P. Merkusii* of Burma; also *Cupressus torulosa*, the seeds of which can be procured from India and Burma; and which are recommended for trial by Dr. D. Brandis, Inspector-General of Forests to the Government of India.

These pines should be put out in the proportion of 1 to 10 of the indigenous species. Planting should be done close, as it is necessary to cover the soil as much and as quickly as possible. The pines will soon overtop the indigenous species, and being in the proportion of 1 to 10 of the latter, will not interfere with their growth, and besides their light open foliage does not throw a deep shade. They are difficult trees to transplant, so care should be taken in that operation.

The nurseries should be established as near to the place where the plants are required to be put out as can conveniently be arranged, at least three years before the forest is worked for the removal of the diseased and injured trees. The nurseries should contain a plentiful supply of young plants of from 2 to 2½ years old, and which should not be put out until they are of that age, as they will then be less likely to be suppressed by grass or be eaten down by deer. These nurseries should be utilized for the rearing of all the stock required, whether composed of indigenous or foreign species. On no account should natural seedlings be brought from the forests, and put down in nursery beds as a preliminary training, as is sometimes done, but the plants should be reared from seed sown in seed beds.

The suggested treatment will therefore consist in clearing off all dead, dying and diseased trees, and restocking the ground artificially, except such portions of it as have already been naturally restocked. Much work of this kind has already been done in the Dayot forests, so that the details of operation are well known, and therefore need not be repeated here.

No regular working of the belts of evergreen forests remaining untouched is possible, except under the system of "selection"; and even that will fail owing to the difficulties of extraction of the timber, and not then without damaging

a considerable portion of the growing forest. Perhaps clear cutting will after all succeed best with them. But it is a treatment which would have to be carefully watched, and carried out judiciously in wide strips, of say 200 feet, over which all growth should be cut and cleared off; and then immediately after the land should be planted over with the more desirable species. A beginning should be made, however, as a tentative measure only, after a good supply of seedlings to transplant have been raised in or near the forest to be cut; a strip should then be marked out in the latter, say 200 feet wide and running east and west across the forest. The trial could best be made at the head of the Dayot evergreen belt. However, as fine examples of the only remaining primeval forests of Mauritius, it is suggested they ought not to be worked for their yield, but maintained intact for their glorious beauty, which surpasses that of all other natural phenomena met with in the Island.

4.—Mountain range of Grand Port and Flacq. Situation, extent and present condition.

Mountain Range of Grand Port and Flacq.—Estimated area, 4859·5 arpents. These forests are composed of a narrow strip, somewhat wider at the western extremity, covering the above range of hills. Upwards of 2,550 arpents of land, in the eastern parts of the range, remain still undetermined. The forests are composed of species similar to those of the Grand Bassin Block, except that Tatamaka (*Calophyllum inophyllum*) and the Ebonies are somewhat more abundant—the elevation of these forests being between 1,400 to 1,900 feet above sea level and the rainfall from 140 to 155 inches per annum.

Their present condition is somewhat as follows: In the western parts, where the land has been determined as being the property of the Crown, the forests are ruined, excepting small tracts lying in the inaccessible parts of the mountains which remain untouched. All below have been worked out; what now remains being the dead and dying trees of inferior species. In the eastern portions, which lie entirely in the mountains, the forests are somewhat better; but they are more or less inaccessible, being moreover protected by law from being cut as they fall within the Mountain Reserve Line.

Future treatment.

For such portions as lie below the mountains, the treatment ought to be the same as that suggested for the forests of Dayot in the Grand Bassin Block. It would likewise be advisable to try here the Indian *Pinus longifolia* (and other eastern Pines recommended), and some of the Eucalypts intermixed with the better class of indigenous trees. The extension of Tatamaka here, however, ought not to be lost sight of.

At present the ground is literally choked with the wide-spreading, trailing, shade-yielding *Rubus moluccanus*, which of course will have to be cleared away before planting out can be done. The plantations here ought to be laid out in lines six feet

apart, the plants standing in the lines at four feet apart, or 1,815 to the acre. Once the young plants start growing it will be advisable to encourage, in every possible way, the formation of a dense undergrowth beneath them.

As regards the forests in the mountains not lying within Reserve Lines, it is only possible to work them on the selection system, provided the cost of extraction of the timber is not prohibitive, but which it will probably be found to be the case.

5.—Piton du Milieu. Situation, extent and present condition.

Piton du Milieu.—The forests consist of a single block measuring 2798·5 arpents, situated at an elevation of 1,600 feet above sea level, with a mean annual fall of 140 inches of rain. The forests are composed of species similar to those already described, except that Natte, Tatamaka and Ebony are the prevailing trees amongst the remaining better kinds. These forests have been extensively worked, and are at present in a state of utter ruin, being likewise choked with *Rubus moluccanus* and a considerable quantity of undergrowth composed of non-indigenous species. The larger trees are more or less damaged and diseased by winds and insects.

Future treatment.

The same as for Concession Dayot. The dead and dying trees to be removed, and the ground planted over with Natte, Makak, Tatamaka, and other valuable timber-yielding indigenous species which prefer a moist, almost wet, soil. All natural regrowth of such, now on the ground, must be strictly preserved, only the dead and diseased trees being removed. Nurseries and seed beds will have to be established for the rearing of the necessary stock for planting out. These forests are not considered eligible for receiving any foreign species, except the Toon (*Cedrela toona*) which would probably thrive in the damp soil.

6.—Mountain Range of Port Louis. Situation, extent and present condition.

Mountain Range of Port Louis.—Estimated area, 3,931 arpents. Situated on the higher slopes and ridges of the Port Louis Mountains; as well as consisting of smaller blocks lying in the Districts of Moka and Pamplemousses.

It is only along the crests and higher slopes that any forest remains, and that is protected by law as the Mountain Reserve. On the whole the growth is fairly dense, but few large trees are to be met with; nor does the composition of the forests in any way differ from others already described. In the lower parts of the mountains, introduced species, now subspontaneous, are common; and which in some parts have reclothed the mountain sides with a fairly dense growth. The *Acacia leucocephala* is now fully established, and overruns the country hereabouts. If not cut down so frequently as it is it would soon grow into small trees 20 feet in height; but since it is in much request as fuel, it has but a poor chance of attaining such dimension.

One of the blocks comprised in this group has an area of 290 arpents, and is the domain on which stands Government House Reduit. His Excellency the Governor, who takes considerable interest in all forest matters, has introduced and reared a large crop of seedlings of the various Eucalypts from Australia. These seedlings are intended to furnish stock for replanting much of the waste land in Reduit, as well as elsewhere. In addition to the large stock of Eucalypts, mentioned above, His Excellency has caused to be raised vast numbers of various other Australian trees, which no doubt will be ultimately of great value to the Colony by their introduction as fast-growing species.

Future treatment.

As the principal mass of these forests lie within Mountain Reserves they have been well protected, and will of course continue to receive similar treatment. For rewooding the lower spurs, and the dry waste lands about Port Louis, the treatment recommended in the case of Tamarind Mountain should be adopted. A composite system of planting and sowing for the more level lands, and sowing in horizontal contour bands for the mountain slopes. There should be no stint in seed sown; and when that of several species of trees are sown mixed together, the chances of failure will be much reduced. What ought to be done at once is to organize a smart, trustworthy seed-collecting establishment, under the orders of the Director of Woods and Forests, so that large quantities of seeds of various evergreen and other shrubs and trees be collected and stored in dry places, ready at hand to be sown as soon as the north-west monsoons begin in December. Meanwhile, also, the laying out of the horizontal beds along the mountain sides be commenced in anticipation of a sufficient quantity of seeds being collected. In the appendices to this Report will be found lists of shrubs and trees both indigenous and foreign, which are recommended for trial, both for rewooding mountains, and for planting out in the forests with the view of restocking them with more valuable trees.

Reduit.

For the waste lands of the Reduit Domain, the formation of extensive plantations of Eucalypts is a sound and wise proposal of His Excellency the Governor, which is with a view of giving their cultivation a fair trial in a selected locality; the finest, perhaps, for such a purpose, in the whole Island. These plantations will be laid out in lines, cleared of all undergrowth, six feet wide bearing by north by south-west, so as to leave the present growth on the ground to shelter the young transplants from the cutting effects of the persistent winds which blow from the south-east. The plants in the lines will stand at four feet apart, and there will be an uncleared space of natural young wood of ten feet in width between every two cleared lines. Should

the young Eucalypts show signs of suffering from the want of more light and less shade, the natural growth will be cut back sufficient to effect this purpose, but no more than what will suffice—the ten-feet wide belts of natural growth being left as screens to break the force of the winds.

Curatelle lands.

In addition to the Crown lands, the Surveyor-General has charge of what are called Curatelle lands, *i.e.*, without any present claimants. There are about 1,684 arpents of such lands under his care. With the exception of one, Coutanceau, which lies between Dayot and Talbot, none of the other estates, of which there are six altogether, contain forests of any height, though they are more or less overgrown with young trees chiefly of subspontaneous origin. Should these estates lapse to the Crown, their treatment as forests will be the same as suggested for the other Crown lands.

Private forests.

A very able, complete and exhaustive descriptive account of these forests has already been placed before the Government, by Mr. N. Cantley, Acting Director of Woods and Forests. As none of the private owners, except one or two, appear to have any notion of retaining their forests in their own hands, or otherwise preserving them, it would be advantageous if the Crown purchased these properties with that view. In fact there appears to be no other course open, if they are to be preserved, but to buy them up.

Such of these private estates—all now more or less ruined as regards the forests on them—which appear desirable should be purchased by the Government, and retained in their hands, will be found briefly and concisely described, as regards their present condition, in a schedule annexed to this Report. For more detailed information Mr. Cantley's admirable map and memorandum might be consulted.

Causes of injury to forest growth. Snails.

It will be necessary before closing this section of the report to say something of the causes which give rise to injury to forest trees and forest vegetation. In Mauritius the young forest growth is liable to be considerably injured by the attacks of *snails*, which not only devour the foliage, but frequently cut back the healthy shoots of young plants. In a plantation near Pamplemousses, in one year the snails destroyed 10,000 young plants. Now the natural enemy of the snail is the *Tenrac*, or Madagascar hedgehog (*Centetes sp.*) In the natural forests, where the *Tenrac* is more abundant than elsewhere, and where it may be seen at all hours of the day hunting about for snails and their eggs, there will scarcely be found a single snail grown large enough to cause appreciable damage to the vegetation. But in quarters where the *Tenrac* is hunted to death for the sake of its flesh by the African Creoles, snails not only abound,

but do incalculable damage. On Crown lands the *Tenrac* ought therefore to be a protected animal, just the same as are certain introduced birds. It must not be forgotten that it is on record and uncontradicted that 10,000 young plants, put out in a plantation, were destroyed in a single season by *snails*. The *Tenrac* alone is able to keep these pests down within reasonable limits.

Deer.

Deer, (*Rusa Tunjuc*) introduced by the Dutch from Java in the higher parts of the Island, do considerable damage to the young growth. In Concession Dayot whole acres of young transplants, of certain species of which they are fond, are found cut back. In future operations it will be necessary to take measures for fencing the plantations. Unfortunately the Deer seem to prefer eating such species as *Makak*, *Natte* and *Ebony*, more so than others; the two first yield decidedly the most durable and valuable timber among the indigenous trees.

Monkeys (*Macacus cynomolgus*.)

These are numerous and exceedingly destructive both to the fauna and flora of the Island; since they devour both the eggs and young of birds which breed in the forests, and whose presence there would otherwise be a check upon the growth and multiplicity of insect life, which is so destructive to timber and forest trees. The monkeys likewise devour and throw down the unripe fruits of all the principal and important forest trees; so that it is scarcely possible to procure ripe seed that will germinate. It will, therefore, be absolutely necessary, in the interest of forest conservancy, to provide the Forest Rangers with the necessary means for destroying or otherwise driving these mischievous creatures out of the forests.

Hares (*Lepus nigricollis*) introduced from Southern India.

These animals are likewise destructive to young plantations in the lower parts of the Island, and are difficult to keep out. They have been found to injure transplants of certain species of introduced Indian origin.

Wood-eating insects.

Wood-eating insects have now multiplied to such an extent that in all probability, failing to find sufficient food in the remaining dead and dying trees, they will attack the living ones. In fact, instances have come under observation where this had been the case. It was found to be the case with some living trees of *Eugenia glomerata* in the forests of Concession Dayot. And was, likewise, observed to an alarming extent in the valuable forests belonging to the Honorable F. H. Pitot above Bois Sec. In these forests, the origin of the mischief appears to have been due to the too sudden opening out of the forests, by heavy fellings and clearings, by which a large gap was created. The trees, standing on that side immediately exposed to the violence of the strong and persistent winds which blow in that quarter, began to die off; and thus gave shelter and

nourishment to various species of wood-eating insects, such as are comprised in the family *Bostrichidæ*, as well as various *Bark Beetles*, belonging to the genera *Scolytus* and *Tomicus* of the family *Scolytidæ*. The attacks of these insects soon killed the trees, which, dying off completely, exposed the next line of trees, immediately behind them, to bear the brunt of the strong winds. In time these also became weakened, losing health and vigor, and were thus prepared to receive the swarms of wood-eating insects, which had now multiplied considerably, and by which they were, in their turn, completely killed off. And so on, doubtless, has run the course of this now serious calamity. In these forests may be seen large trees, (*Calophyllum inophyllum*) of magnificent development, entirely killed ; and as far as could be seen of it, the evil was gradually, but too surely, spreading onwards and upwards into the hill forests, where to end it is hard to say. In the forests, lying above the immediate line of attack, were found young and comparatively healthy trees of various species, in which were discovered swarms of beetles and their larvæ, and which appeared to belong to the genus *Tomicus*, though to what species we are unable to say owing to the want of books of reference. These appeared, as it were, the pioneers whose first attacks would shortly be followed up by the more robust Bostrichidians coming up in the rear.

There are, besides the foregoing mentioned, numerous other species of Coleopterous insects, whose larvæ feed on the woody stems of trees, especially such as have received injury, or the health and vigor of the trees have otherwise been impaired. Such insects belong to the families *Buprestidæ*, and the long-horned or capricorn Beetles (*Cerambycidæ*), all of which are represented in Mauritius by several genera containing numerous very fine species.

Preservation of insect-eating birds.

Before concluding this notice of the more prevalent forms of insect life capable of inflicting grave and serious injury to the forest growths of Mauritius, a word might be said on the necessity there is for affording all the protection the law can give to the insect-eating birds, whose presence in the forests, though few they be, doubtless has an appreciable effect in reducing the number of insects which might otherwise complete the cycle of their existence. Of insectivorous birds there are but very few in the Island, and which belong to some half dozen species.

White ants.

These are very abundant, attacking decayed and decaying timber. They belong to species which differ from the Indian forms, by constructing their galleries and globular nests with decayed wood, and likewise arboreal in their habits. The huge globular excrescences, so frequently met with on decaying trees, are the habitations of these creatures.

Micro-fungoidal diseases.

The timber is very liable to the attacks of *dry-rot* and other fungoidal forms which cause considerable destruction to it. Very few of the larger mature trees, now met with in the forests, are free from *dry rot*. In fact it is the rule rather than the exception to find timber attacked by it. Once commenced the destruction goes on, unless the diseased part be carefully cut out so that none of it remain, otherwise the *fungus* will again spread. The climate of Mauritius is peculiarly favourable to the development of such parasitical *fungi*, several forms of which likewise appear on the leaves and twigs of living trees.

Creepers and Epiphytes.

Creepers and Epiphytic plants of large size are not numerous, and therefore are not active agents in effecting any appreciable damage to the forest trees. Two climbers of robust habit, however, are found within the forest regions—the *Cnestis glabra* and *Roussea simplex*, but their occurrence is rare. Amongst the herbaceous twiners are several species which damage the young growth, and which will require attending to in all newly formed plantations. Of *Epiphytes*, capable of injuring fully developed forest trees, may be cited the several species composing the genus *Ficus*. These are likewise not of common occurrence, and therefore the injury they do is inappreciable, though it would be well to make it a standing order to all Forest Rangers that Creepers and Epiphytic plants of destructive habits, wherever met with, should be killed. This will be done by cutting off the stem, in the case of a creeper, close to the ground, and then splitting and smashing up the stump to prevent its shooting out new stems. *Epiphytes* may be cut down and removed if they are in a position where they can be got at. Each Forest Ranger should be provided with an axe of the kind common in Mauritius, having a chisel-cutting edge at one end and a hammer head at the other; without his axe in his belt no Forest Ranger should stir out on his rounds.

Winds.

These are very destructive in Mauritius, because of their persistent action whenever they set in blowing, which is in winter from the south-east quarter; they then constitute what are called the south-east trade winds. In all exposed localities tree vegetation suffers considerably from them; they are cold and cutting, and as they blow with some force, amounting sometimes to continuous gales, the damage they do in cutting over and retarding growth is considerable. In some parts of the Island this is especially the case; and it will be observed that, owing to these winds, the branches of trees exposed to windward have become arrested in development, and that growth has taken place on the opposite side instead, thus rendering the trees lop-sided. The

effect of such growth, on the timber produced by such trees, is that the fibro-vascular bundles of woody tissues, instead of being regularly arranged in concentric circles around the stem, are formed in excess on the sheltered side of the tree, while similar bundles on the windward side are few and imperfectly developed, so that the timber of trees grown under those conditions is less valuable, where strength and durability are requisite qualities. The force and persistency of these winds during a great part of the year also cause the taller forest trees, which, seeking the light, force themselves above the general canopy of forest foliage, and in which situation they are then exposed to the full action of the winds,—to throw out buttresses, and their stems are thereby rendered irregular and of fluted formation. The stems of such of the taller trees, as *Tambalacoque, Colophane, Tatamaka, Natte* and *Makak*, are familiar examples.

Shelter belts against winds.

In all instances where young plantations are to be established in localities exposed to these winds, shelter belts must be first established, placed at right angles to the direction from which they blow. Such belts are easily formed, and may be twenty feet in width, planted with *Casuarina, Telfaria, (Tetranthera monopetala,)* Bamboos, *Jamlongue, (Eugenia Jambolana)* or some of the quick growing hardy Australian trees. Unless such protection belts are first established, it is very doubtful ; otherwise, if laying out plantations in such localities is not literally throwing money to the winds.

Hurricanes.

These sometimes visit the Island, and may appear at any time between 1st December and 1st April ; the destruction caused by these revolving storms are simply incredible ; all tree vegetation, sugar plantations, orchards, in fact everything offering any obstacle or resistance, go down at once before them. No forest, unless growing together in a compact mass, could withstand them. Hence the necessity, whatever is done artificially in the way of getting up young forests, to plant thickly and to allow no room for these winds to find a way into them.

(To be continued.)

Rate of growth of Sal in Chota Nagpore.

On a recent tour through the forests of Chota Nagpore, the opportunity was taken to measure Sâl trees wherever possible, with a view to ascertaining the average rate of growth. The best countings were obtained in the Singbhúm Forests in a portion of the Anandpur Estate, which the Thakúr was working for timber to build the new jail at Chaibassa. Careful countings were made on eight stumps with the following results :—

No.	Girth with *bark.*	Thickness of bark.	Mean diameter, *wood only.*	Age.	No. of rings *per inch.*
		in.	in.	years.	
1	8′ 6″	1·25	29·5	122	8·3
2	6′ 6″	1	26·5	116	8·8
3	6′ 0″	0·75	21	72	6·8
4	6′ 10″	1	23	120	10·5
5	6′ 6″	1	21·5	93	7·8
6	...	...	22	100	9·1
7	6′ 5″	1	22	93	8·5
8	7′ 8″	1	24	115	9·6

giving an average rate of growth of nearly 8·7 rings per inch. The rings on the clean cut section were particularly well marked for Sâl, and the stumps recorded presented no difficulty in counting. Many more stumps were really examined, but the measurements were not recorded where in the least doubtful.

No. 1 gave the following measurements for the different thickness of 10 to 10 rings, counted as the greater radius only. Owing to indistinctness on some radii the mean radius measurements were not procurable. These measurements show a comparatively uniform growth :—

Yrs.		Yrs.	
10	$1\frac{10}{16}$	80	$1\frac{13}{16}$
20	$1\frac{5}{16}$	90	$\frac{15}{16}$
30	$1\frac{4}{16}$	100	$1\frac{3}{16}$
40	$1\frac{3}{16}$	110	$1\frac{4}{16}$
50	$1\frac{12}{16}$	120	$1\frac{3}{16}$
60	$2\frac{4}{16}$	122	$\frac{3}{16}$
70	$1\frac{6}{16}$		
		Total	$17\frac{1}{2}$

In the same forest the following measurements of a log 50 feet long were recorded :—

	Feet.	Inches.		Feet.	Inches.
Girth at ...	0	114	Girth at ...	30	86
	5	101		40	82
	10	88		50	78
	20	86			

This shows a decrease of 23 inches in 45 feet, from 5 feet to 50 feet, or omitting the first ten feet, where the trunk evidently broadened out—10 inches in 40 feet, or ¼ inch decrease per foot of height. Above 55 feet a big knot unfortunately prevented further measurements. To show the size to which

timber in the magnificent Saranda Forests can attain, the following measurements of a big tree may be given :—Height, 125 feet; girth, 121 inches, and this was not a very exceptional case. In the adjoining Government Reserve no large fellings were going on, but the following smaller trees were cut and measured—

At Rongo on the outer Western Range of the Saranda hills :—

	Feet.	Radius.	Rings.	Rings per inch.
On the hill ridge in a dry place, exposed to hot winds (C. 3,472) about	1,500	2 in.	24	12
At the foot of the hill, locality comparatively moist (C. 3,473) at about ...	1,000	2½ „	18	7·2

On the slopes of the Ankua hill overlooking the Koina valley :—

	Feet.	Radius.	Rings.	Rings per inch.
On the summit ... .. (The age of this is known, for the place was cleared in 1863 for a survey point.)	2,700	2¼ in.	17	7·5
On the northern aspect slope, good soil, laterite	3,000	3¾ „	29	7·7
On a western aspect, rock laterite, but very little soil over it	1,800	4 „	62	15·5

These three specimens have been kept and marked C. 3478, C. 3479, and C. 3480 of the Dehra Dûn collection. On the hill above Kurkutia in the Kolhán Forests a sapling, or rather shoot, was measured (No. C. 3490), giving 1⅛ inch radius to 9 years of growth, or 8 rings per inch of radius.

These measurements seem to show that the rate of growth of Sâl in Saranda may be taken to be 7 to 9 rings per inch of radius for trees growing on good soil in sheltered localities, and 12 to 15 rings for trees growing in more exposed conditions. For good soil, therefore, we may consider 80 to 100 years as the age at which Sál may be expected to reach 6 feet in circumference, exclusive of bark.

In the Palamow Forests, which are all young and chiefly composed of stump shoots from saplings which have been constantly cut over while yet young, before the forests were reserved, a few countings were also made with the following results :—

Forest.	Radius.	No. of rings.	Rings per inch.
Kumandi Reserve (C. 3434) ...	⅞ inch.	6	7
Chanpi Forest (C. 3441)	3⅛ „	23	7·5
Seemah Reserve, Neturhát (C. 3440) 3,000 feet	2 „	20	10
Seemah Reserve, Henar Valley (C. 3444) Shoot 33 feet high	2½ „	10	4

These show that, at any rate, at first the growth of shoots is fast if the locality is favourable, and that even at 3,000 feet on the laterite of the Neturhát plateau, the growth is not bad considering the conditions. That large timber can be grown in Palamow is evident from the measurements of old trees on

the Jaigir plateau at about 2,500 feet in a sacred grove. These trees showed a height of 100 feet to a girth of 10 to 11 at 4 feet from the ground. In estimating, however, the probable growth of Sâl in Palamow, it would be too much to count on an average of even 7, much less 4 rings per inch, and it will be safer to take the probable age of trees at 6 feet in girth as about 80 years in good, 120 years in moderate, and 150 years in exposed and high localities. In Chota Nagpore the effects of forest, especially in low-lying spots, just below the hills, are very remarkable. In the Seemah Reserve whole areas of young Sâl forest, evidently of promising growth, are often thus destroyed. But in more exposed places, frost is seldom very destructive, and it would seem that, in Palamow at any rate, it is only the low-lying moist places near to high hill ranges, which are much affected.

The counting of annual rings on freshly cut stumps in Chota Nagpore is by no means difficult, but the markings of the annual rings seem to disappear as the wood cut seasons or the stump gets older, and it is then difficult to say always what are annual rings, and what are only lines containing fewer or more pores, but not marking annual growth.

J. S. G.

On the Restoration of Denuded Forests in Kolhapur.

On looking over the map of the Bombay Presidency it will be seen that Kolhapur is a Native State, situated on the range of the Sahyadri Mountains, and bounded by the district of Sattara on the north, and by that of Belgaum on the south. It is ruled over by a Mahratta Chief, a descendant of the great Shiwaji, the founder of the Mahratta rule in the Deccan. The present Chief being a minor, the affairs of the State are managed by a Native Karbhari (minister) under the general supervision of the British Resident.

The total area of the Kolhapur State is about 3,000 square miles, and the revenue is about 30,00,000 rupees, including that of the subordinate jaghirs. The country is intersected by long ranges of hills, branching from the Sahyadri (Western) Ghats, and running perpendicular to it in the east. These hills form the water-parting of the several tributaries, which take their rise in the Western Ghats, and empty themselves into the celebrated Kistna river, supplying water for irrigation for a considerable area of land under sugarcane cultivation in the rich valleys through which they run. The importance of protecting the tree vegetation on these hills and on the slopes of the Ghats cannot, therefore, be denied.

The State authorities, having been quite alive as to the necessity for immediate action in that direction, obtained the services

of a native forester from the Bombay Forest Department, and with his advice introduced a system of forest management both in the interest of the State and its people; gradually, though steadily, introducing reforms as the people became reconciled with the altered circumstances.

The Forest Department was started in March 1878, and subsequently organized in November following, after the forests were fully inspected, and their capabilities ascertained by the Forest Officer. The Department at first employed itself on the most important and preliminary work of forest demarcation, which has since made considerable progress.

Simultaneously with the forest demarcation, the Department was authorized to bring certain forest areas under strict protection, and to provide for the maintenance and improvement of the reserves; and, though little progress has yet been made in that direction, it is nevertheless satisfactory considering that the Department is in its infancy, that the new staff of subordinates have to be taught and initiated into the rudiments of forestry, and that they have to acquire, by experience, a knowledge of the cultural requirements of at least some of the important forest trees.

At the outset, it must be said that the object of the State Forest Department is not to create ornamental plantations by incurring a large outlay, but simply to undo the mischief caused by recklessly cutting down, and afterwards burning the first jungle trees and vegetation for kumri (or what is otherwise called dhaya) cultivation and for other purposes; by re-clothing the bare hills, or large open blanks in the forest reserves with anything that will grow on them, so as to prevent the consequences which may be expected to arise from denudation. Nevertheless it is desirable to grow valuable timber trees so as ultimately to supply the market with timber. At the same time the cultivation of fruit and other useful trees yielding valuable minor produce, such as myrobolams, lac, gum, &c., has not been neglected, as they would not only considerably add to the resources of the State, but would afford employment to the poorer and wilder classes, who are solely dependent on the produce of the forests for their maintenance; but that, too, seems at present to have denied to them by Providence, which punishment they deserve for carelessly and recklessly destroying all vegetation near about the place of their abode.

When first creating the forest, jungle trees and vegetation, it seems as if nature were cognizant of the wretched condition of the poorer classes residing in the remote corners of the country, and encouraged, and gave, as it were, a prominence to the growth of such species of tree as would have (if they had been spared) provided in the shape of edible fruits, roots, flowers, leaves, &c., for the requirements of the

people, whose indolent habits precluded them from adopting a better mode of cultivation than the well known and pernicious system of kumri.

For instance there is a variety of climber called "Kusar," (*Jasminum arborescens*) formerly to be seen everywhere on the line of the Ghat Forests, but now gradually disappearing. It flowers in March, and immediately afterwards commences to bear, and is loaded with seed in such quantity that it supplies food to at least three-fourths of the population residing near the Western Ghats. The noteworthy fact in connection with this climber is, that its boiled seed is said to be as nutritious as any of the common food grains produced in the Mawal country, such as *wari*, *sawa*, &c.; besides, while quenching the appetite, it is considered by the hill people to be a cure for any derangement in the stomach. On account of this good quality, the people eat it after boiling it several times to make it palatable, as it is bitter in its raw state. There are other varieties of vegetation affording similar means at other times of the year; but it is needless to describe them all here—suffice it to say, that about three-quarters of the population near about the Ghats subsists on the produce of the forests for about six months in the year.

The above fact was, therefore, laid at heart by the Department in conducting the sowing and planting operations wherever the capacity of the soil operated upon permitted of its being observed.

Four different methods, *viz.*, broadcast sowing, sowing of seeds by dibbling, direct sowing in pits and seed holes, and raising of seedlings in nurseries for planting out, were suggested for adoption in replenishing the denuded hills with jungle trees and vegetation; but how far each succeeded in securing the object in view is to be gathered from the result herein recorded.

During the past Fuslee year, that is during the rains of 1879, small nurseries were established in different localities, mostly to raise Teak and Bamboo seedlings for subsequent transplanting; but the cultivation of other useful trees, such as Amba (*Mangifera indica*), Fanas (*Artocarpus integrifolia*), Bhendee (*Thespesia populnea*), Oondee (*Calophyllum inophyllum*), Chandan (*Santalum album*), &c., on a small scale, was by no means neglected.

The Bamboo and other seeds germinated after they were put into the ground, but the Teak, as was sown in its natural state, took one complete year to come up, so that it came up thickly when the regular rains of 1880 commenced to fall.

The Teak seedlings, as soon as they had borne six leaves, exclusive of the cotyledonary ones, which was by the middle of July last, were, as well as the seedlings of other plants one

year old, removed from the nurseries, and *transplanted*, as shewn below, during the monsoon of 1880 :—

Name of the Sub-division in which the Reserves are situated.	No. of Plants.		
	Teak.	Other kinds.	Total.
1. Kurweer	26,000	600	26,600
2. Bowda	8,000	1,000	9,000
3. Bhoodagad	7,000	...	7,000
4. Panhalla	...	400	400
5. Malkapur	3,000	400	3,400
Total	44,000	2,400	46,400

The smaller and tender plants which sprouted up later were retained in nurseries for removal in the following year.

The bamboo plants had grown four to five feet in height, and were quite capable of being planted out during the last rains; but as no bamboo seed could be procured for sowing during the current year, it has been considered desirable to retain them in nurseries until the rains of 1881, when they will be able to throw out new shoots from the main stock. These shoots it will probably be possible to separate, so that they may be planted out separately, and thereby increase the number of bamboo seedlings to at least double the present number.

The approximate number of bamboo plants now growing in different nurseries is 11,000, and these will be available for transplanting at the commencement of the rains of 1881, and by the end of that monsoon season they will, it is hoped, have taken a firm hold of the ground, and be in a position to stand better against the dry summer heat without watering, than would have been the case with tender and younger plants, such as they were during and before the rains of 1880.

The broadcast sowing was resorted to in replenishing the narrow belt of the forests, lying along the Sahyadri Range, which, though irregularly stocked and opened with large blanks here and there, is still capable of being regenerated by self-sown seedlings, provided the seed is scattered over broadcast, or dibbled into the ground, wherever required, to assist the natural reproduction.

The information as regards the area sown under the above system during the past two years, *viz.*, 1879 and 1880, is contained in the following table :—

Year in which the sowings were effected.	Approximate area operated upon in acres.
In the rains of 1879	4,700
Do. do. of 1880	3,200
Total	7,900

The sowing in all the reserves taken in hand in the year 1879 had to be repeated, and it will have to be continued in some until the whole area is thickly covered with new growth.

The result of the sowings effected during the last and the current year is very encouraging in localities where the young forests could be saved from being burnt over, especially in the case of Bowda, Katalee, Shengaum, and Nishnap reserves, which need not be sown any longer, but require to be protected from fire and cattle only for some time.

The change which has been made in the appearance of some of the Ghat Forests, since they were subjected to a regular treatment, is conspicuous even to a casual observer.

There the Hirda (*Terminalia Chebula*) trees naturally abound, and as they are likely to yield a handsome yearly revenue to the State, the Department was induced to put several cart-loads of myrobolams in the ground, resulting in the sprinkling of a new growth of Hirda in all the reserves, and more especially in those of Shengaum and Guzapur.

In a locality further east, outside the above belt, where the hills have become perfectly bare, the ground for sowing and planting had to be prepared a little more elaborately than was the case in the western part of the district. Here the simple method of sowing in pits and seed holes was followed with great success.

As usual the Teak seed that was put into the pits before the commencement of the rains in 1879 germinated only on the setting in of the monsoon of 1880, as has been the case with nursery sowings; and at present about 75 per cent. of the pits contain one or more seedlings. The seeds in other pits are likely to sprout hereafter. Some time must, however, elapse before the result of the direct sowing can be compared with that of transplanting, and we are able to decide which of the two systems can be adopted with most advantage.

Of the Teak transplants put out in the rains of 1879, 40 per cent. have survived without watering. They are now growing six to twelve inches in height, and appear to be sufficiently robust to warrant a hope that they will push ahead without further assistance.

As the Teak in its natural state does not grow alone, it was intermixed with other species of a hardy and fast-growing character, such as Khair (*Accacia Catechu*), Jambul (*Eugenia Jambolana*), Palas (*Butea frondosa*), Wehela (*Terminalia belerica*), Siras (*Albizzia Lebbek*), Koombha (*Careya arborea*), Kajoo (*Anacardium orientale*), etc.

Almost all of the above plants dried down during the hot season, and the forest subordinates, who were not familiar with the habits of different trees, felt at first discouraged at what appeared to them a complete failure of their sowing operations. It was, however, explained to them that certain trees have the properties of throwing out new coppice shoots from their roots,

and that many of the plants, which they found to have been killed by frost or extreme heat, would spring up after the setting in of the monsoon. Of course precautionary measures, such as loosening the surface soil and covering it with grass and weeds during the dry season, were required to be taken *to prevent the soil drying too much, and to prevent the evaporation* of the subsoil moisture.

In the month of June last the plants, which once seemed to have died, began to throw up new shoots to the astonishment of all the forest subordinates, and in the month of August last it was found that about 25 per cent. of the whole number of plants other than Teak have finally succeeded, and this is no doubt a very satisfactory result when it is remembered that the sowings were effected on a poor soil and that the plants were not irrigated.

Among the species selected as companions for **Teak,** Kajoo (*Anarcardium orientale*) seems to be deserving of every attention for sowing in the forests. It is said to be a native of Brazil; but it is now quite naturalized in all parts of the Southern Konkan, where it is cultivated in groves near the towns, and round about the village temples. It is stated in the Bombay Flora that the wood is much used in France for fine cabinet work, under the name "Bois d' Acajou," though it does not seem to be in use here in carpentry.

The tree bears sweet smelling flowers succeeded by pea-shaped fruit of a yellowish red colour. *A fine spirit is prepared* in Goa from the fleshy peduncle by distillation. The nut hangs at the end of the fruit outside, and is about an inch long. It is edible and wholesome when roasted, and forms an article of trade and commerce. It is said that these nuts are used for imparting a flavour to Madeira wine, and that they are also known to yield, by expression, an edible oil equal, if not superior, to almond oil, and certainly by no means inferior to the ground-nut oil.

The pericarp of the nut produces a black acrid oil, which possesses caustic properties. *This oil is applied to timber to* prevent the attacks of white ants.

An astringent gum is exuded from the trunk of the tree to the extent of five to twelve pounds annually, which require to be collected when the sap is rising.

It is said that it forms a good varnish, and is peculiarly useful where the depredations of insects require to be guarded against. It is said that in South America book-binders wash books with a solution of it in order to keep away moths and ants.

Apart from its being useful as above described, the tree appears to be well adapted for cultivation on *dry stony ground on account* of its fast growth and hardy character. Five hundred seed grains were, therefore, procured and dibbled into the pits and seed holes at the commencement of the monsoon season of 1879.

Almost all the seeds germinated within a fortnight, and by the end of October following the plants had grown up from one to two feet in height, and so firmly established themselves by striking deep roots, that I find the percentage of casualties, even under unfavorable circumstances, is very small indeed compared with other species similarly situated.

The subjoined statement will exhibit the area taken in hand during the current year for direct sowing in addition to that sown over last year, and the number of pits and holes prepared for the purpose in different places :—

Name of the Sub-division in which the Reserves *are situated.*	AREA OPERATED UPON		Approximate number of plants now surviving from those raised in 1879 after deducting the casualties.	Number of plants grown in 1880.	REMARKS.
	In 1879.	In 1880.			
	Acres.				
Malkapur ...	350	100	19,500	72,420	The casualties among the plants grown in 1880 will not be actually known till after the setting in of the next monsoon.
Bowda ...	350	50	18,000	40,000	
Kurweer ...	210	175	21,000	80,600	
Panhala ...	410	130	30,500	90,500	
Bhudagad ...	15	250	2,000	96,500	

The seeds selected for sowing in the above pits and holes during the year 1880 were the same as last year, and in the same proportion, with the exception of Kajoo nuts, which were used in large quantity this time. Four hundred thousand Kajoo nuts were put into the ground just before the advent of the last rains. They came up luxuriantly as usual, and the seedlings have now attained a height of from twelve to eighteen inches, and promise to grow with vigour.

If the cultivation of the tree in question be continued for a further period of ten years on the same scale as has now been adopted, and if the Department succeeds to grow at least *one hundred thousand trees* every year, allowing 75 per cent. for casualties, etc., that is 25 per cent more than has been found by the experience of last year (but this has been done more for being on the safe side) while estimating the future yield, there is every reason to believe that, while on the one hand the cultivation of *Anarcardium orientale* will lead to augment the resources of the State forest revenue by the sale of its produce to a considerable extent like the Hirda nuts, on the other it will cover the present naked hills with vegetation, perhaps unequalled as far as beauty and productiveness is concerned, for the tree is very ornamental in appearance, and its cultivation easy.

Considering the tree is both economically and commercially useful, the Forest Department will be justified in estimating that each tree will at least yield, even under unfavorable

circumstances, four annas worth of produce, consisting of, as has been said before, nuts, oil, fruits, gum, etc.

It appears that the cultivation of the Cashew-nut tree was never tried on the barren hills in the Deccan, and there is every reason to believe that this is the first time that it has been tried for forest planting with such considerable success as to warrant further experiments being made.

One noteworthy fact to be kept in view in connection with the Cashew-nut tree is, that it bears fruits and nuts at the age of five or six years, so that any speculation formed as to the value of its yield must take into consideration the probability of such yield commencing at an earlier age than is usually the case with most trees.

It is no doubt desirable that, wherever extensive planting operations are to be undertaken, it is better to adhere to the system of direct sowing of seeds in pits and seed holes (even in the case of teak sowings) on spots where it is to grow into a tree than to raise seedlings for transplanting; but at the same time it must be remembered that it would be undesirable to do away with the nursery system altogether, until the results of the two methods could be compared so as to be able to lay down a definite plan for future operations.

However, the experience gained last year having shewed a tendency to confirm the above opinion, an attempt is being made to gradually abandon the nursery system, instead of giving it up all at once, for the reasons already stated. Four new small nurseries were, therefore, established during the rains of 1880 to secure plants for planting out during the ensuing rains, in which Teak, Chandan, Funas, and *Pithecolobium Saman* seed have been sown.

A few *Pithecolobium Saman* plants, which the Forest Department raised in bamboo baskets in the beginning of the monsoon of 1879, were transplanted during the rains of 1879. Some of these have grown to a man's height during the course of one year, while the remainder were twice browsed down, and in one or two cases broken off by village cattle who had entered the plantation at night soon after the plants were put out. The cattle were seized and put into the cattle ground, but the growth of the plants was retarded by the injury done to them. They threw up fresh shoots with renewed vigour immediately after the setting in of the rains of 1880, and are now growing capitally as if to make up the loss.

The aggregate expenditure incurred on account of the above undertaking amounts to Rs. 3,225, which sum would appear very small indeed compared with the result obtained; but it should be stated that a considerable portion of the work was done by the members of the regular subordinate forest establishment, and hence the small extra outlay.

NATIVE FORESTER.

Select Extra-tropical Plants readily eligible for Industrial Culture or Naturalization.

By Baron Ferd. von Müller, K.C.M.G., &c.

This is an Indian edition of an Australian work which was some years ago widely circulated in India, and has, it seems, been specially printed by the Government of India for circulation. As an index of information regarding economic plants, it is likely to prove very useful, though we are convinced that if the writer intended his work chiefly for Indian enquirers, it would have been better if he had visited India first. We have not had time to examine the book very closely, but here and there a few indications occur which shew that a greater acquaintance with Indian botany would have benefited the book, and made it really more useful. In the genus *Acer* we note that, while some space is devoted to the European and American maples, those of India are dismissed with a short note on *Acer niveum*, a Burmese species, and a remark that several others worthy of cultivation occur on the mountains of India. Surely the common north-western species, *A. pictum* and *A. cæsium*, and the beautiful north-eastern species *A. Campbellii*, probably the largest of the genus, deserved mention before the comparatively rare *A. niveum*. Some similar remarks might be made on the treatment of the Indian oaks. We note that the author still persists in the old story that *Æsculus Hippocastanum*, the horse-chestnut of European gardens, is a native of the Himalaya. There are only two species as yet known in India—one is the common tree of the North-West Himalaya, *Æ. indica*, and the other the beautiful *Æ. punduana* of the swamp forests of Northern Bengal and Assam; while *Æ. Hippocastanum*, as may be seen at page 104 of the "Forest Flora," has never yet had its original home definitely settled.

In speaking of *Arundinacea falcata*, Baron von Müller talks of the stems "attaining a diameter of only four inches": we doubt if it ever, in the most exceptional cases, reaches one inch, while most of the stems we have seen must have had a diameter of even less than half an inch. As for its reaching forty feet in height, we doubt if it ever goes much beyond ten. Talking of bamboos, we were rather amused to read under *Bambusa arundinacea* that its seeds are useful for feeding fowls. The fowls would have a bad time of it if they depended much on bamboo seed for food, for the general flowering occurs, as far as is known, only at intervals of about thirty years. The whole information regarding bamboos is rather misleading, for instance *B. vulgaris* is spoken of as "the large unarmed bamboo of Bengal," the fact being that *B. vulgaris* is not an Indian species at all, and is only occasionally found in cultivation.

And how is it then that he has omitted it from the list at page 302? Turning from the bamboos to the canes, we find the latter represented only by *C. montanus* of Sikhim, a species which is now extremely rare and difficult to procure. No notice is taken of the other good Himalayan kinds, of the common *C. Rotang* or the fine *C. latifolius* of Burma.

If any of our readers are acquainted with the system of manufacture of Tea as carried on in India, they will derive considerable amusement from the perusal of the description at page 54 of *Camellia Thea.* We will not discuss the statements therein gravely printed, except to say that the author has yet to learn the meaning of such terms as "Pekoe" and "Souchong," and to draw notice to the "Tea-preparing machine." This must be a wonderful invention if it can do all that seems suggested by the writer; if he can put the green leaf in at one end, and turn out tea at the other, his machine ought to be a fine speculation!

In the article on Sissu, Panjab foresters may be interested to hear that according to the statement of a Madras forest officer "in the Panjab artificial rearing of Sissu is remunerative at only fifteen inches annual rainfall with great heat in summer and sharp frosts in winter." Baron von Müller seems to have made a great discovery when he says that our well-known "Amaltas" tree, the common *Cassia Fistula*, has been "traced by Sir Jos. Hooker to the dry slopes of the Central Himalaya."

Curiously enough, the cocoanut palm is omitted, while a place is found for *Borassus* and *Arenga*; and while describing a large number of temperate fine flowering shrubs, no notice at all is taken of the Rhododendrons. These are, however, matters concerning plants of which in India we know something more, and we have no doubt that, as far as regards Australian and other plants, our readers will find the book, as we have, a good book of reference, though it can never hope to compete with such really good works as the "Treasury of Botany."

IV. Notes, Queries and Extracts.

Indian Turpentines.—It is only recently that some of these have been chemically investigated; and it is now interesting to learn that the crude turpentine of *Pinus khasyana* from Burmah has been examined, with the result so far that the liquid or "oil of turpentine" obtained from it, is remarkably pure and free from smell.

It has apparently an unusually great amount of action on polarized light, the rotatory power of a 200*mm.* column being about + 76° for light of refrangibility of the D line, whereas that of French oil of turpentine is only 60°, and American oil 30°.

The oil from *P. longifolia* apparently has a much lower rotatory power (13°).

We understand that Sir J. Hooker has applied for larger samples for chemical examination.

Perhaps some new hydrocarbon may be discovered: who knows?

The Kodza (*Broussonetia papyrifera*) is extensively cultivated throughout the Empire of Japan. It thrives best on dry sunny slopes, and is propagated by cuttings. About three years are allowed to elapse before gathering the first annual crop, which is done about November, by cutting off the shoots close to the ground. These are cut into short lengths and steamed in huge iron pots, so as to loosen the bark. This bark is stripped off, the outer dark-coloured rough skin is scraped off, and used for the coarser qualities, and the finer parts are washed, kneaded, and then bleached in the sun. The last is boiled in a lye, made from the ashes of buckwheat straw generally, to free it from gummy or resinous matter, and is then well pounded between stones or with mortars, some of which are worked by water in districts where such power is to be obtained. The fibres now being separated the knotty portions are removed, and the pulp resulting is steeped in pure water mixed with mucilage, obtained from the bark of *Hydrangea paniculata* and the root of *Hibiscus Manihot*.—*Paper Makers' Journal.*

It appears that the climate of Bangalore and the higher parts of the Mysore plateau is better adapted to the Carob tree than that of the Panjab. Some pods, grown in the Lál Bágh gardens at Bangalore, were lately submitted to Mr. Baden-Powell, and two of these returned with the remark that "pods, equal

to these, had been grown in the Panjab," are considerably below the *average* of the Bangalore pods. Indigenous seed from these Bangalore trees has, this year, been sown in the Government plantations, and some of it has gone west to the coffee planters, so that there is every chance of the tree being thoroughly tried in Mysore. The writer's experience with plants raised from European seed is, that they are hardy in Mysore, only when on good soil and in low-lying situations. Restricted to land of this description there is ample room for the economic planting of Carob as a hedge-row plant, and the value of the pod to the half-starved cattle of the hot weather, and the totally starved cattle in times of drought, would be incalculable. How the tree will acclimatize is a subject which admits of much speculation, and one in which it is to be earnestly hoped the facts will be recorded —K. H.

HINTS CONCERNING SAWS.—A saw just large enough to cut through a board will require less power than a saw larger, the number of teeth, speed, and thickness being equal in each. The more teeth, the more power, provided the thickness, speed, and feed are equal. There is, however, a limit, or a point where a few teeth will not answer the place of a large number. The thinner the saw, the more teeth will be required to carry an equal amount of feed to each revolution of the saw, but *always at the expense of power.* When bench-saws are used, and the sawing is done by a gauge, the lumber is often inclined to clatter and raise up the back of the saws when pushed hard.

The reason is that the back half of the saw, having an upward motion, has a tendency to lift and raise the piece being sawn, especially when it springs and pinches on the saw, or crowds between the saw and the gauge, while the cut at the front of the saw has the opposite tendency of holding that part of the piece down. The hook or pitch of a saw tooth should be *on a line from one-quarter to one-fifth the diameter* of the saw; one-quarter pitch is mostly used for hard, and a one-fifth for a softer timber. For very fine-toothed saws designed for heavy work, such as sawing shingles, &c., even from soft wood, one-quarter pitch is best.—*Mechanic.*

WE see that Colonel Pearson, formerly Officiating Inspector-General of Forests in India, has been recommending to Government that Forest Officers on leave should visit the works in the French Alps, which have been undertaken with the view of reclothing denuded areas and preventing landslips. Colonel Pearson's proposals, which we reproduce, have been accepted by the Secretary of State, who states himself prepared to sanction the deputation of Forest Officers for the purpose :—

I am induced by the late disastrous landslip at Naini Tâl to do myself the honor of addressing you with a view, if possible, to the deputation from time to time of any Forest Officers who may be at home from India on furlough to visit the works in the Basses and Hautes Aples (especially near Barcellonette and Embrun) with a view to the prevention and repair of similar givings-way of the mountain sides in the Alps. There are huge landslips in the Alps which have covered the vineyards and habitations for three to four kilometres along the bottom of the valleys, and have destroyed property to an enormous value, but which have been successfully treated by various works, and especially by planting the hills around and above them, thereby preventing the water, when there is a heavy fall of rain, from forming a torrent, which is the main cause of these catastrophes. Some of these landslips must be three or four times the size of that at Naini Tâl, and it is impossible to suppose that the same means which have been effective in the Alps should not equally succeed there.

THE gradual extinction of the forests in the United States, while no adequate provision is being made to replace them, is again attracting attention in that country. In the State of New York wood is becoming scarcer and more inaccessible every year. In many States the forests on level ground have for the most part disappeared, and only remain on high hills and mountains, where they are not easily reached. Apart from the fires which make havoc of the forests, the large consumption of wood in various industries is of itself sufficient to account for their disappearance. Some interesting information on this point is given by the United States *Monetary Times*. To make shoe-pegs enough for American use consumes annually 100,000 cords of timber; and to make lucifer-matches 300,000 cubic feet of the best pine are required every year. Lasts and boot-trees take 500,000 cords of birch, beech, and maple, and the handles of tools 500,000 more. The baking of bricks consumes 2,000,000 cords of wood, or what would cover with forest about 50,000 acres of land. Telegraph-poles already erected represent 800,000 trees, and their annual repair consumes about 300,000 more. The "ties" of the railroads consume annually thirty years' growth of 70,000 acres; and to fence all the railroads would cost 45,000,000dols., with a yearly expenditure of 15,000,000dols. for repairs. In the meantime, straw lumber has been manufactured to some extent in Kansas, and is said to answer the purpose very well. If this manufacture comes into general use, it will to a certain extent relieve the pressure on the forests.—*St. James' Budget, February* 1880.

EFFECTS OF FOREST DENUDATION IN WESTERN RUSSIA.—"In consequence of the reckless and extravagant felling of timber that has prevailed throughout Western Russia during the greater part of the present century, several of the streams feeding the Dnieper have become dried up, whilst others contribute so little water to the great river that its navigation has already suffered serious prejudice, and is in some portions of its course threatened with absolute interruption. Rocks and sandy islands in great number, forming sections of its bed, may now be seen where a few years ago from twelve to fifteen feet of water hid them from view. As the Dnieper traverses and largely contributes to the prosperity of no fewer than nine Russian provinces, or "governments," this falling-off in its dimensions and capacities is in reality little short of a national calamity, for which, however, Russian landowners and the *Mir* have only to thank their own ignorance and improvidence. Enormous tracts of forest abutting on the Upper Dnieper have been within the last few years completely denuded of trees, and the huge woods formerly covering the districts watered by the Lower Dnieper, now for the most part arid steppes, vanished before the axe so long ago that men of middle age scarcely remember their existence. Similarly the forest lands of the Beresina, Pripet, and Desna, three important feeders of the Dnieper, have been laid bare by their boyar and peasant proprietors to such disastrous purpose that those once broad and potent rivers have dwindled to insignificant streams. In tolerating such wholesale destruction of timber the Forest Department in the Russian Home Ministry cannot but have been grossly neglectful of the supervision and control which it is fully empowered to exercise over private as well as imperial property throughout the Czar's dominions."—*Journal of Forestry, November* 1880.

WOOD PULP AND PAPERMAKING.—Two kinds of wood pulp are used in the manufacture of printing paper, respectively designated as "mechanical pulp" and "chemical pulp." Any ordinary wood which is fibrous, free from knots and decay, and is easily disintegrated, is suitable for making chemical pulp, though the whiter the wood and the less acid it contains the better. The wood is cut into small pieces, diagonally with the grain, by revolving knives, just as logwood is cut for dyeing purposes. It is then treated with a super-heated bath of caustic alkali, then bleached, and afterwards subjected to the same processes as are clean rags. In making mechanical pulp no chemicals are used—not even lime. Any ordinary whitewood is suitable for the purpose, but poplar is preferred, although the dark heart is not used. The process of manufac-

turing is the most stupid that could have been devised, yet it is cheap. Water power is used, and it is estimated that one cord of wood, with two stones or emery wheels, and thirty-horse power, will produce the equivalent of from 1,000 to 1,200 pounds of dry pulp per day, with the labour of three men—one to attend to marking and sawing the wood, one to attend the stones, and one to look after the pulp. The wood is used soon after it is cut, or, if seasoned, it must be steamed. The sticks are pressed endwise against the stones or wheels, and with a plentiful supply of water they are literally ground to pulp, thus destroying the fibre. Unlike the chemically prepared article, this pulp is not allowed to dry before being used. The damp sheets are folded, packed in bundles, and sold, with an allowance of 40 per cent. for the moisture. To manufacture paper from it, the addition of some kind of fibre is essential—say from 20 to 80 per cent., according to the kind of paper required. Good printing paper is made from the chemical pulp without the addition of any other fibre, and the use of it is desirable in making even the best book paper. Some excellent book paper is made of 40 per cent. of this pulp, and the printing paper now being used by the government is made wholly of white spruce pulp. Machinery of the capacity for making say 7,000 pounds of rag paper per day will turn out from 12,000 to 13,000 pounds per day, if 40 to 50 per cent. of pulp is used At the present time chemical pulp is almost as expensive as rags in manufacturing ordinary printing paper.—*Philadelphia Record.*

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The Mulberry Tree as a source of Food for Silk-Worms.

BY C. H. LEPPER, F.R.G.S., M.R.A.S.

WHEN I commenced this little pamphlet I had not intended enlarging upon the Mulberry Tree, but as the subject grew I began to think that a few words on the food-supply, whilst yet on the trees, would not be out of place, though in the standard French Works on Silk-Worm Rearing the Mulberry finds but little attention given it. Gradually I came to the decision that, as the experiment, in the interests of which this pamphlet is published, is to be undertaken and in part carried on by inexperienced though enterprising people, I ought to devote a considerable portion of the pamphlet to the Mulberry, to assist the enterprise from the very beginning as much as possible. Then, remembering the great dearth of scientific classification, or perhaps it would be more correct to say the over-classification of the different so-called varieties of the Mulberry tree, and remembering that as a food-supply for worms *local* conditions require special attention in selecting the most suitable kind of Mulberry tree, I began to fear that I might only create confusion in the mind of the reader, and possibly distrust or want of confidence in the experiment, and thus commence by prejudicing people against what it was my very object to attract them in favor of, *viz.*, Silk-rearing in Northern India. This I feared the more as, knowing there had been no scientific or technical attention paid to the special *local* conditions, I should be powerless to name what varieties should be planted and in what manner cultivated. Then, on further consideration, I decided that it was best to place the whole subject fairly before the reader to the best of my ability, in the certainty that those who would have been happy to blindly follow a leader, on his simple statement, would not be deterred from starting on a track of their own when attracted by the desire to succeed, and guided by the light of their own experience, assisted as much

as I can assist them by what information I can afford of the manner of proceeding in *other* countries.

I thus leave them free choice to select any or all of the different systems employed and free to compete with each other for the greatest share of success.

I would merely mention in passing that Tea began under similar conditions, and its present position amongst the Industries of India justify me in hoping that sufficient enterprise will be shown to give sericulture a fair chance of developing the great future I feel certain would, in that case, open out for it—a future that cannot but be tempting to owners of land in suitable localities, when it is remembered that the whole year's labour is condensed into two months, from which profits should be obtained quite equal to what the majority of Tea companies can show after working throughout the whole twelve.

When it is remembered too that, so far as Dehra Dún is concerned, and possibly Kangra Valley also, the silk-season happens just at the Tea-planters' slack time, when labour is usually plentiful, and that silk-rearing may be undertaken without clashing with the interests of their Tea-plantations, and serve indeed as a means of finding employment and so of retaining for the Tea-season, what might otherwise for the time prove surplus labour, surely many owners will be found anxious to fathom the merits of such a tempting investment. Then, again, many must own land unsuited for Tea, yet possibly perfect for Mulberry cultivation.

There are many so-called varieties of Mulberry trees, and many more sub-varieties, and these are in some cases known by different names among botanists. It would be practically useless giving all the names of the various kinds here, and would only lead to confusion and a useless enlarging of this little monograph.

In order, however, to prove that I am not thus trying to shirk the trouble which might be thought was my object in thus omitting what some might think an important piece of information, I will just give a few examples of the confusion that exists amongst botanists, &c., and thus leave the reader to see for himself how little good would come of mentioning all the so-called varieties.

Firstly then, Dr. Brandis in his *Forest Flora of North-West and Central India*, says on page 408, speaking of the Mulberry tree: "The chief product of this tree, however, in the "Punjab, Beluchistan and Afghanistan, is the fruit, of which "there are many varieties, sweet and acid, and of all shades of "colour, from white to a deep blackish purple. The large white "kind of the Peshawar Valley (*Shah Tút*) is one of the best. "The following kinds are cultivated in Beluchistan, according

"to Stocks: *Siah*, colour black and white mixed; *Bedana* (seed-"less); *Pewandi* (grafted), with delicious pearly small white "fruit; *Shah Tút* (Royal Mulberry); *Khar Tút* (Jackass Mul-"berry.) It remains for further inquiry on the spot which of "these varieties should be classed under *M. alba* and *nigra*, and "it is not impossible that it may, in the Punjab and Afghanis-"tan at least, be found impracticable to maintain the distinc-"tion between the two species."

Then again in describing *Morus indica*, Dr. Brandis says, page 408, of his *Forest Flora:* "Leaves pubescent when young, *rough* afterwards, with minute round raised dots, &c., &c.," whereas the late Dr. Roxburgh, in his *Flora Indica*, page 659, says of the leaves, in describing the *same* tree: "*Smooth on both sides!*"*

Then again Dr. Brandis, on page 408, speaking of *Morus indica*, says: "Dr. Stewart considered this as merely a variety of *M. alba*;" and on page 409, speaking of its habitat, names *Japan*; yet in the Report of the Italian Commission to Japan, as quoted later on in this pamphlet, it is distinctly asserted there is no *White* Mulberry in Japan! Roxburgh gives 7 varieties, Count Dandolo 18, and Dr. Brandis, probably recognizing the impossibility of distinguishing what may now simply be the effects of cultivation, leaves most of his varieties unclassed, botanically speaking, as quoted above. Then, again, the distinctive marks between the Black and the White Mulberry are so very slight, and the uncertainty that must exist when trying to decide from a specimen whether such distinctive marks in the specimen under observation are permanent characteristics of the tree to which it belonged, renders true classification particularly difficult, save perhaps to a local observer well up in the special study of Mulberry trees. This difficulty again is not diminished by the fact that there are four kinds of White Mulberry in the matter of colour of fruit, two kinds bearing white or whitish fruit, one red and one black! Dr. Brandis, in the quotation I have given above, gives the *Shah Tút* as one of the best for fruit in the Peshawar Valley. This agrees with the native opinion in the Dehra Dún, which also gives the preference to the leaves of the *Shah Tút* for food for silk-worms; whereas in the Gurdaspur District of the Punjab the natives, according to information conveyed to me, prefer the fruit of the *Bedana* to eat as being sweeter than that of the *Shah Tút*, although the latter bears the largest fruit. In the Gurdaspur District, too, they prefer the leaf of the *Bedana* and the *Khatta Tút* to that of the *Shah Tút*, as being more tender for the worms, although they say, that when within eight days of spinning their cocoons the worms seem to take as readily to the *Shah Tút* as to the others.

* These italics are mine.—C. H. L.

I think I have sufficiently exemplified the reasons I have given for not going too minutely into a description of varieties. It seems a great pity that a tree that might some day prove of such importance in parts of India, has not received the attention of really scientific botanists, which it unquestionably merits.

Since the Mulberry tree first became cultivated in France for sericultural purposes, ideas as to the different kinds thought best suited have been subject to several changes. *Morus nigra, M. multicaulis* (sometimes called Philipine, Philibert, Perrotet) and *Morus alba* have all been in favor, the latter having kept it finally. The *multicaulis* is considered as a variety of *M. nigra*, and has two sub-varieties. It gives the earliest leaf in spring, but its leaves are too aqueous to be of the best for sericulture.

It is my impression that we ***must not*** look to following any established or fixed rule in planting merely on the experience of European rearers; the kinds of Mulberry *they* have decided suited *their* climate, soils and seasons the best.

From what information I have been able to gather, there seems no hard and fast rule to go by, and we must look to experience under *our own* conditions, of climate, soils and seasons, and the preference shown by the worms, to point out to us our best variety or varieties for planting to suit our conditions. *One thing is quite evident, and* that is what suits one silk-rearing locality will not always suit another, and this endorses my opinion that, as we have hitherto had no scientific experience of sericulture in Upper India, leaving out Bengal, we must act on our own judgment, and by carefully working out statistics, learn what suits our circumstances the best. Even what may be best for the Gurdaspur District of the Punjab may not be the best for Dehra Dún, and indeed from my present meagre local information I am led to understand that such difference between the two places does exist in the matter of suitable *Mulberry trees.*

To assist you in coming to a conclusion for yourselves as to the best kinds to plant, after you have had some experience of different varieties, the following are the points to decide you in favor of a particular kind of Mulberry; and if you find a variety giving you all these characteristics of a suitable tree, you may have confidence in planting that variety. I cannot do better, I think, than give you a translation of a chapter from Count Dandolo's great work on silk-worms, as being one of the very best authorities :—

"*Notwithstanding what authors have* been able to say at different times, it is now demonstrated that the only leaf which is suitable to the silk-worm* is that of the White Mulberry.

* In Europe he must mean, as in Japan they only use *M. nigra.*

"The first silk-worms which were reared in Europe were nourished with the leaf of the Black Mulberry, the only kind it appears which was cultivated then, notwithstanding that it was known the White was being cultivated* in Greece.

"However, it was not long before the cultivation of this latter variety was introduced in all the temperate regions of Europe.

"This Mulberry presented three advantages over the Black; firstly, that of being able to use the leaf sooner, and consequently avoid the feeding of the silk-worms being prolonged too far into the hot season; in the second place, that of giving much more leaf in less time; lastly, the quality of the leaf produced the quality of silk most approved of by the manufacturers, not that the quality of the silk depends solely upon that of the food, as it also depends upon the temperature in which the worm has been reared.

"As there exist several varieties of Mulberry, one may suppose that these differences should exercise a greater or less influence on the prosperity of the silk-worm.†

"In effect there are five different substances in the leaf of the Mulberry:—

"(*1st.*) The solid *Parenchyma* or fibrous substances; (*2nd.*) The colouring matter; (*3rd.*) Water; (*4th.*) Saccharine matter; (*5th.*) Resinous matter.

"The fibrous substance, colouring matter, and the water, save as much of the latter as serves the wants of the animal, are not, properly speaking, nutritives of the silk-worm.

"The saccharine matter is that which nourishes the insect, which makes it grow big, and which forms its animal substance.

"The resinous matter is that which separates itself gradually from the leaf, and which, attracted by the organism of the animal, accumulates in it, purifies itself, and fills insensibly the two reservoirs or silk-sacks which form an integral part of the silk-worm.

"According to the diverse proportions of the elements which constitute the leaf, there results that cases may present themselves in which a larger weight of leaf may prove less profitable to the silk-worm, as much owing to the want of nourishmens as to the want of silk-producing material. For example, the leaf of the Black Mulberry, hard, coarse, tenacious, which is still given to silk-worms in some of the warm countries of Europe, such as in diverse places in Greece, Spain, Sicily, &c., produces a silk very abundant, of which the thread is very beautiful, but *coarse*.

* The geographical error of not allowing Greece to be in Europe is of no consequence, and should not be allowed to prejudice opinion against Count Dandolo's information on his pet subject.

† And as there are several varieties of silk-worms, why should not each variety have its own quality of food? One does not feed all kinds of horses alike, or the same in different climates.—C. H. L.

"The leaf of the White Mulberry, when planted in high grounds, exposed to cold and dry wind, in light soils, gives generally an abundant crop of silk, strong, very pure, and of a beautiful quality.

"The leaf of this same Mulberry, planted in damp places, on flat lands, in fat rich soils, gives a *little less silk, less beautiful* and less pure.

"These are the most general differences; there are others relative to the topography of the country.

"The less the leaf contains of nutritive substance, the more the silk-worm must consume to arrive at its development.

"It results from this that the silk-worm which consumes a large quantity of innutritious leaf, must be more fatigued and more in danger of falling ill than the one which eats less leaf, but of a more nutritious kind.

"As much may be said of the *leaf which, although having* nutritive parts, contains little resinous substance. In this case, the silk-worm could nourish itself well and become large, and at the same time not produce a full "fleshy" cocoon well covered with silk, and strong, that is to say proportioned to the weight of the worm, which happens sometimes owing to bad seasons.

"Notwithstanding all this, my experience proves that in a last analysis, all things being equal otherwise, the qualities of the lands produce a really very small difference on the quality of the leaf. That which will be always true, is that the cause which influences most the fineness of the silk is the degree of temperature in which the silk-worm is reared. I have already said it above, and I shall demonstrate it in the latter part of this work.

"Not only must you note the difference in quality which there is, in general, between the leaf of Mulberry trees placed in lands of different nature, and plucked in different seasons, but also the difference which you find between the leaves of different kinds of Mulberry trees planted on the *same site.* I have found, for example, that with equal weights of leaf, the leaf coming from the large-leafed Mulberry was a little less nutritious.

"I have observed that, after that one, comes the Mulberry which has large enough leaves, plump, and of a dark green colour. When these Mulberry trees are not exposed to a dry air and in light soils, they become very well covered with leaf, but they have not much material for making silk. It seems that nature finds it easier to produce a leaf which abounds in nutritive substance rather than in a resinous or silk-making substance.

"I find that the best leaf of the Mulberry, no matter of what kind, is that which is called "double"; it is small, little, succulent, of a dark green, shiny, and contains but little water,

which is easy enough to find out by drying it: the tree, to commence with, furnishes a large quantity.

"Generally the rearer is fond of those kinds of Mulberry trees which give the heaviest leaves, or the largest, without thinking that it is neither the water nor the fibrous tissue of the leaf which nourishes the silk-worm and renders the cocoons weighty, but in reality the substances I have named above instead. Here we must remember another observation of fact: it is under equal conditions the old Mulberry trees produce always a better leaf than the young trees. Much better indeed, as the trees become old, of whatever kind they may be, their leaves becoming always smaller and smaller, they improve so much that they finish by becoming all of one single quality.

"Up to now I have heard talk of the leaves of grafted Mulberry trees. The leaf of the naturally grown Mulberry is that which, in equal weight, and under the same circumstances, contains always a much larger quantity of nutritive substance and of silk-forming material.

"This leaf, in considerably *less* quantity than that of the grafted Mulberry, gives nevertheless better results. I do not know that any one, up to the present time, has made an exact comparison on a large scale on this important point.

"Another comparison which should fix the attention of Mulberry-cultivating proprietors, is that the grafted Mulberry, especially when old, produces a much larger quantity of White Mulberries than the natural-grown one.*

"This fruit which, in general, the worm doesn't eat, forms none the less a portion of the weight of the leaf which the producer buys or sells. Notwithstanding this there are strong reasons† for preventing the general use of the natural grown leaf, *i.e.*, from trees not grafted.

"The worst leaf obtainable from the Mulberry, and one that is always disastrous to the silk-worm, is that which is covered with manna, an evil state which comes from sickness or an excess of health in the tree‡. I should never advise any one giving such leaf, except in case of paucity of supply; and then it should be well washed and dried with care.

"Leaves marked with rust do no harm to the worm. But it has the serious inconvenience of increasing greatly the refuse on the rearing-shelves. A large number of Mulberry trees can be seen attacked by this disease, particularly when they are in damp lands or in ill-ventilated places. The worm eats this leaf as well as that which is healthy; the only difference is, that it only chews the healthy part, avoiding carefully that which is "rusty." Those who have no other quality of leaf are

* As usual of course, as the nutritive power decreases, the reproductive "instinct" increases.

† These reasons are not of weight for India.

‡ Might not this come from the deposit of some insect?

obliged to give it in larger quantity, in order that the worms should not fatigue themselves in seeking their food. These insects would suffer if they were given leaf damped by rain or dew to eat. Whatever may be the leaf that is given to the silk-worms, the greatest care should be taken to prevent heating, or fermentation, either in the plucking, or in the storing of it, before giving it to the worms.

Leaves can be easily dried by being spread on withering changes on Tea plantations, say 3 inches *thick*, and *turned over every half hour, care being* taken not to bruise the leaves and not to allow either withering, heating, or fermentation to begin; every effort should be used to preserve them as fresh as possible.

"A high degree of fermentation changes for the worse, more or less, the nutritive substance of the leaf, which then becomes less nourishing. The leaf should not be left for long pressed in the baskets or cloths in which it is carried in from the plucking.

"Leaves are easily preserved two or three days in cool places, if they are a little moist and protected from the air, as in cellars, godowns, ground floors of bungalows, &c., provided they are not too stacked, and are turned from time to time. They must be prevented from losing their freshness owing to too much dryness in the place where they are kept, or by too much air; they rot also from too much damp and from being too stacked. It is very advantageous to have a suitable place to preserve the leaf two days, and even three in case of necessity."

In selecting your varieties of Mulberry, look out for the following conditions :—the produce of leaves; the produce of silk from a given quantity of leaves; the facility and rapidity obtainable in plucking the leaves; the power they have of retaining their freshness for more or less time. The nourishing and silk-producing qualities are of course evident by comparing the produce of silk from given quantities of leaves, as *explained already. Look out for the* varieties preferred by the worms themselves, as they show marked preference for certain kinds, and this may show different results in different soils, lay of lands and climates. Take care, however, that the age of the leaf given is consistent with the age of the worm to which it is given, or your conclusions will be based on false data. In this, as throughout the whole process of sericulture, treat the worms as though they have habits which nature has intended for them, and don't try to change the course of nature by trying to change these habits in any way. Find out their *natural habits, and try and facilitate their work of making silk* for you, by giving them as little *other* and *useless* work to do as possible, hence the desirability of giving them the best leaf obtainable.

Mark the time of year each variety of Mulberry comes into leaf, and always have a small proportion of early ones to begin on, and thus enable you to commence rearing as soon as danger from frost to the leaves is passed, and so avoid carrying the rearing on into the hot weather.

From a French Work I extract the following;—"The Mulberry grows in all soils, but its vegetation is more or less vigorous, and its leaf is more or less *good*, *in* each. It only refuses to grow in marshy lands, too calcareous, too superficial—and consequently too dry. It allows the use of arid, pebbly slopes (not of course situated on continuous rock). Its produce there is not abundant but of excellent quality. In rich, fresh deep soils its leaf is too watery.

"It is multiplied by sowing seed, by budding, by layers, and by cuttings.

"By the first means the most vigorous plants are obtained, the most durable, and those that resist drought the best.

"Budding gives trees more productive in leaf and of a more rapid growth.

"Layers produce a more certain success than budding, but a sufficiently large quantity cannot be obtained from the same area.

"Lastly, cuttings, less prompt and less sure than seed-sowing or budding seldom succeed save with the varieties *multicaulis* (Philipine) Hybrid and *Lhou*; they are chiefly used to obtain 'dwarf' or 'middle-sized' trees.

"'Dwarf' trees and 'middle-sized' trees refer in French to systems of cultivating the Mulberry, *e.g.*, they have 'full-sized', 'middle-sized,' 'dwarfs,' and 'hedges,' representing each a different system of planting and of cultivation.

PLUCKING.

On the method of plucking I translate the following:—

"Plucking commences in the morning, after the dew has disappeared, and it should be given up at night as soon as the mist falls, and should not go on during rain.

"For trees of any size ladders should be used. The plucker furnished with a bag or sack attached to his waist and kept open by a piece of circular wood, or wooden-hoop of an old cask, mounts his ladder, seizes successively each shoot by its base, and *slides his hand rapidly from below upwards, detaches thus without trouble all the leaves which he then places in his sack. When this receptacle is filled, it is emptied into a cloth placed in the shade or covered with another cloth. When this in turn is filled it is tied up by knotting the four corners and carried *at once* to the rearing-shed in order not to allow the leaf to wither."

* The Japanese do not believe in this, as being bad for the trees. See translation later on.

PRUNING.

On the manner of pruning I translate the following :—

"As soon as the crop is over, all the shoots, which gave the leaves that have been plucked off, are pruned just above the last two buds nearest the base; this is the *Summer-pruning.*

"The tree brought up or reared with 12 to 25 branches always retains its primitive goblet shape. In the following spring (in India this should probably be about the end of December) all the poor looking twigs are suppressed, and those too near each other thinned out; all the dry twigs are taken off, and the leaves that have come on the shoots, two and two, which have grown since the Summer-pruning."

This, of course, is purely a Utilitarian process.

I translate the following account of the Japanese treatment of Mulberry trees from a "Report on Sericultural Studies" made by an Italian Mission in the interior of Japan, dated Yokohama, 1st July 1869, and quoted by that great authority on the Diseases of Silk-worms. M. L. Pasteur, F.R.S., and member of the Institute of France, from the *Revue Universelle de Sericulture; September* 1869 :—

"The *Morus alba*, or White Mulberry, does not exist in Japan, where they only know the Mulberry tree bearing* black fruit, with a leaf sometimes round sometimes indented.

"It is found everywhere, the length of the lanes, on the banks of canals and in masses clumped in the middle of cultivated fields. It seldom grows higher than 9 ft. 9 in.; the Japanese cultivate it ordinarily in thickets, and they cut off the branches at the level of the ground, covering then the roots and manuring them, either with human manure or with the sweepings of the rearing-sheds dried first in the sun. The same manner is used for trees allowed to grow to 'Full-size,' and in that case they spread it on the land round the trunks of the trees.

"The reproduction of the trees is not obtained in Japan from seed but by suckers. In spring they cut down to ground level, a plant about 8 years old at least, from the lower trunk, and roots recovered with earth spring up the new shoots. These again, in the following autumn, are cut at the trunk and serve to form new plants which are manured with human night soil."

From the work of a Swiss gentleman whom I knew years ago when in Japan, when he was engaged in business there in the purchase of silk, I translate the following, which may be taken for what it is worth, as coming from a so-to-speak amateur source :—"The cultivation of the Mulberry (in Japan) is rare

* Not that this is a sign of its belonging to *M. nigra.*

in the neighbourhood of the sea, whether it be that the Japanese think such situation unfavorable to the tree, or perhaps owing to the conditions of the soil.

"A soil somewhat sandy, mixed with earth and slightly damp, is regarded as very appropriate to this culture, such as the banks of streams, and places where water runs easily. The Mulberry in Japan thrives best in the 'dwarf' state; the head of the trunk hardly rises a foot above the level of the ground, and the branches reach about three or four feet only in height. It is said that by this system the leaves become more tender and more suitable to the health of the worms. Rarely they allow a tree to arrive at its full growth, however it may often be seen about five feet high. They carefully remove surplus branches which might make the foliage too dense; and they carefully prevent any settlement of birds or insects in the trees. When the trees have reached forty years of age they are torn up and replaced by young ones.

"The propagation of the Mulberry trees is carried on in the three following ways: By *Seed sowing* they carefully wash the fruit, mix them with wood ashes, and plant the mixture; by *plants* in utilizing to this end the young branches * and proceeding as in Europe. These two ways are but seldom employed; the most extensively adopted is the propagation by *layers* (Marcottes). This is done towards the end of June, by bringing down the branches of a dwarf tree, and partly covering them with earth to make them take root. Ten months afterwards the plants thus obtained are transplanted into a site, manured and prepared for their reception, where they remain temporarily for one year, and from whence they pass to their final destination. A year after this transplanting they commence to use the leaves for feeding silk-worms.

"The manuring of the trees takes place several times throughout the year.

"Budding is nowhere employed so far as we could find out, though it is spoken of in certain old Japanese books. To *feed the worms they cut the branches so as to leave a sharp* clean end, the leaves only being plucked off at the house.

"The Japanese believe that it injures the tree to pluck the leaves direct from the tree on account of the wounds it causes to the stem.

"All rearers do not own their own leaves. Many of them buy their leaves at the special market for this business. The sellers bring their leaves to the village in the morning, and offer them down the principal street, in the shade of the houses. Prices vary considerably according to the quality and state of the trees; sometimes 4 *bous*, other years 12, 16, and even more per horse load of 200 catties. (The *bou* is equivalent to about

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* Suckers.

9 annas; the catty to $1\frac{3}{4}$ English pound weight.) Plantations of Mulberry trees, properly speaking, are only found near Yonésawa and Onéda; *elsewhere they are usually in* groups, more or less extensive, along hill-sides and streams, so that they give an idea of being quite a second rate cultivation."

French statistics relating to Mullberry cultivation.

The following few statistics may prove interesting to some as showing how important the dimensions of Mulberry cultivation may become to a country suited to it by nature.

In the Cevennes near Vigan (Gard) France, some Mulberry trees of "full-size" kind planted about 23 feet apart in quincunx, produced the following yield of leaf each year:—

at 3	years old	$3\frac{1}{5}$	kilos;	at 13	years old	$75\frac{1}{10}$	kilos.
,, 4	,,	$11\frac{2}{5}$	,,	,, 14	,,	$77\frac{3}{5}$	,,
,, 5	,,	$17\frac{9}{10}$	,,	,, 15	,,	$84\frac{1}{2}$	,,
,, 6	,,	$25\frac{7}{10}$	,,	,, 16	,,	$88\frac{3}{5}$	,,
,, 7	,,	$32\frac{7}{10}$	,,	,, 17	,,	$91\frac{4}{5}$	,,
,, 8	,,	$42\frac{3}{5}$	,,	,, 18	,,	$94\frac{3}{5}$	,,
,, 9	,,	$48\frac{3}{10}$	,,	,, 19	,,	$96\frac{1}{2}$	,,
,, 10	,,	$52\frac{4}{5}$	,,	,, 20	,,	$98\frac{1}{5}$	,,
,, 11	,,	$64\frac{3}{5}$	,,	,, 21	,,	99	,,
,, 12	,,	69	,,	,, 22	,,	100	,,

say averaging $57\frac{1}{5}$ kilos per annum each tree, or roughly taking 1 kilo, to equal 1 seer 2 chittacks, say 65 seers per annum each tree; taking from this 15 seers for loss and waste, leaves 50 seers or at above distance apart $102\frac{1}{2}$ maunds of leaf per acre. One chittack of eggs or "seed" should require 40 good trees of 50 *seers each tree*, or say two chittacks of "seed" would require an acre of such trees, planted as above, 23 feet apart. Two chittacks of "seed" should produce $3\frac{1}{8}$ maunds of green cocoons worth Rs. 30 per maund, if good, or value of one acre's produce planted as above, Rs. 93-12-0. But this planting at such a wide distance is to allow of cultivation of other crops between the trees, and out here where the land would probably be given up entirely to Mulberry cultivation, on the spots set apart for it, 12 feet by 12 feet, 13 feet by 13 feet, or at outside 15 feet by 15 feet, would probably be the distances found amply sufficient, as large trees are undesirable owing to the difficulty of plucking.

If then the acre be planted about 12 feet by 12 feet, one acre should produce about 12 maunds of green cocoons, value Rs. 30 per maund, if good, or say total value of one acre's produce would be Rs. 360 *per acre*! What other cultivation can offer such a return for only two months' work in the whole year? off land unfit for almost any other crop! Of course there are risks in this as in every other pursuit depending upon circumstances over which man has no control.

In this climate, however, and with such suitable conditions as there are to hand, the very home of the Mulberry (unlike France to which it was exotic) and with freshly imported *healthy* "seed," the risks of sericulture, apart from the faults of carelessness and inattention, should be reduced to the minimum.

The following figures illustrating the huge proportions the industry attained in France before its collapse, show how valuable it is to a country, and what temptations it must have offered ever to reach such figures. Especially remarkable too when it is remembered that only a portion of France, not one-half I believe, is suited to the industry from climatic causes, &c.

In France then, in 1852 there were 69,687 acres under Mulberry trees.

In 1862, *i.e.*, 10 years later only, it was nearly double, *viz.*, 121,542 acres!

In 1852 they counted 17,762,906 isolated Mulberry trees, and over 7,264,000 yards of Mulberry hedges for silk-worm feeding, or say over 4,127 miles of Mulberry hedges.

In 1852 the amount of leaf used by rearers was about 5,700,850 maunds, or say roughly 456,068,000lbs., or over 203,600 tons, representing in value Frcs. 33,506,018, or say roughly at 2 frcs. per rupee, Rs. 16,754,509 for *leaf* alone—a sum which has gradually been decreasing year by year with the ruin that has fallen upon sericulture in France, from disease amongst the worms, the effects of the war and other causes.

This fabulous sum to be thrown direct into the hands of peasant proprietors, and their labourers, is surely enough to tempt any Government lucky enough to own suitable land and climate, to exert every possible effort to almost force attention to such a promising industry, the more especially as it is now hardly a case of competing with France, since the industry is almost destroyed there. It is merely a case of replacing here and under much more favorable auspices, when cheapness of labour and suitability of climate are taken into account. And this part of India, unlike Bengal, can, I firmly believe, produce silk of equal and possibly superior quality to the average best qualities produced in France, at a much less cost in every way.

Bengal silk being very inferior in reputation has, of course, suffered in the "hard times" of late years, but with the quality of cocoons obtainable in the north west of India, in the Sub-Himalayan country, at the cost they should be produced at, there should always be ample margin for the play of markets without fear of loss, once the trees are fairly into bearing, and planted with a view to economy in carriage of leaf—a most important item for consideration, and one I cannot lay too much stress upon.

Plantations *must* be near the rearing-sheds to ensure economical working, and freshness in the leaf supplied to the worms. To Europeans therefore desirous of taking up the experiment, I would offer the advice that they leave room for their rearing-sheds *on* their Mulberry plantations, and ask them to bear in mind that many small rearing-sheds are better than one large one, as large masses of worms, when collected in one place, have been found to run greater risk from disease than smaller collections.

Leave the sites for the houses running North and South, and the door end to be at the North, so that the sun's rays can never enter by the door and scorch the worms. The front of the house should face the East.

Long before the trees are ready, however, I hope to be able to offer Part II of this little pamphlet to those whom it may interest, and which will treat, on the best arrangements, for rearing-sheds and on the feeding of the worms.

Before saying, *au revoir*, I would mention that I have taken no notice of the Bengal system as from climate, &c., I trust rearers here will be able to employ a very different class of worm, and follow Japanese or European systems rather than that of Bengal, if they do not have to strike out a line for themselves, as this will be the earliest crop in the world of the class of worm I hope they will succeed with.

In concluding Part I of this pamphlet I would point out as an encouragement to Europeans thinking, yet hesitating, about attempting Mulberry planting with a view to sericulture in proper time, that Messrs. Lister and Co., who have taken this matter up with such energy, good will and hope for the future, are ready to supply the want that has hitherto acted as a serious check on the advance of this industry in the North West of India (I include the Punjab and Kangra Valley) *viz.*, that of a local market.

There need be no fear of there ever being a case of production exceeding the demand of the said market, as Messrs. *Lister & Co. have their agents in every silk-growing country* in the world to assist in collecting sufficient for their vast requirements, and enterprise here will never, practically speaking, be able to produce collectively more than Messrs. Lister and Co. can take with pleasure, and at rates that will pay the rearers handsomely, always provided, they in return make a business of producing *good* cocoons, and do not run counter to their own interest by producing none but inferior ones. In this Messrs. Lister & Co. only expect what the purchasers of teas now look for, *viz.*, the best possible general average, and in return can offer cash in full value *on the spot.*

Examination of the Annual Rings of Chir:

Being an Extract from a Report on the Tons Chir Forests.

BY A. SMYTHIES, *Assistant Conservator.*

Fellings of Chir had been made along the Tons in 1874-75, and advantage was taken of this circumstance to examine the stumps that were left, and to count the annual rings. Many stumps had been burnt, and others had decayed, but it was found possible to count the rings on 153 stumps, situated partly on Karoli Flat, partly on adjoining hill sides. On 64 stumps the rings were counted along two radii, a short and a long one, and the mean result was taken; on the remaining 89 it was found practicable to count the rings along one radius only, the one chosen being as far as possible a mean one. The counting was carried out by a Patrol of the Deoban Forests, named Jaman Singh. This man was employed for three months on similar work in 1878, near Deoban, and in both cases his results were constantly tested by me, and were found to be most satisfactory. I have no hesitation, therefore, in adopting his figures as substantially correct. It would have been quite impossible for either Mr. Murray or myself to undertake this counting within the allotted time, as it required 28 days to complete.

With these remarks I now proceed to analyse the results, of which full details are given in Appendix *B*.

The radii along which the rings were counted were 27-5, 5-5, 8-25, 11, 13, 15, and 18 inches in length respectively. The first four radii correspond to girths of 1 foot 6 inches, 3 feet, 4 feet 6 inches, and 6 feet, allowing something for the bark (see letter in *Indian Forester*, Vol. IV, No. II, p. 192). The other three are convenient lengths without corresponding to any particular girth classes. At the same time the thickness of the bark of each stump was measured, and it was found that the mean was rather less than one inch, but in many cases the thickness had been diminished by fire and other accidents. If we allow one inch as the average thickness, then the real girths, outside the bark, corresponding to the above radii, would have been 1 foot 11$\frac{1}{2}$ inches, 3 feet 4·8 inches, 4 feet 10$\frac{1}{7}$ inches, and 6 feet 3$\frac{3}{7}$ inches. That is allowing the same thickness of bark for a pole of the 1$\frac{1}{2}$ foot class, as for a *tree of the 6-foot girth class, which is not fair;* while one is too great, the other is too small, as the bark of a living tree 6 feet in girth would be about 1$\frac{1}{2}$ inches thick instead of 1 inch.

It will be observed from the figures here given that many of these stumps belonged to trees which were either suppressed or had suffered such injury that their growth was severely checked. Nos. 12 to 19 are an instance of this, and it becomes a question for consideration in working out a mean result as to what we are to exclude as suppressed trees.

The group above mentioned will furnish us with good data to go upon; they all stopped short in their growth at comparatively small dimensions, or in other words, they shew small girths at advanced ages; they vary in age from 139 to 199 years, and in diameter from 23 to 27½ inches. Comparing them with other trees, it is obvious that they were suppressed before they attained a girth of 6 feet, and for the purposes of the present analysis, we shall take as a suppressed tree, any tree which required 130 years or more to reach a girth of 6 feet. On looking over the list, it will be found that all trees which come into this category required a great number of years to attain small dimensions, and that the average number of rings per inch is as a rule over 12.

It is a matter for consideration whether it would have been better to have taken some other age as the limit, 120 years, for example, Nos. 46, 85, 139, 145, 146 and 149 shew on an average over 12 rings per inch and attained a girth of 6 feet between 120 and 130 years of age. There are, however, many trees which shew over 12 rings per inch, taking an average for the whole life of the tree, which nevertheless attained a girth of 6 feet within 120 years, including several which reached this girth within even 100 years. Thus we cannot include among suppressed trees *all* which shew an average of 12 rings and more per inch of radius. Nos. 1, 8, 11, 24, 30, 35, not to mention others, amply prove this. The number of stumps examined is too few to admit of a general rule being laid down on the subject, and it must be left for further experience to decide this question. For the present, however, we have adopted the limit of 130 years, as it seems to apply pretty generally, and we have worked out the mean results, both including and excluding suppressed trees as defined above in each of the three following cases:—

(1). Taking all the trees together.
(2). Taking the 39 trees on Karoli Flat.
(3). Taking the 114 trees on the hill side.

(1).—*Including suppressed trees.* 153 *stumps.*

Length of radius ...	2·57	5·5	8·25	11·	13·	15·
No. of rings	17	37	66	104 (1)	126 (2)	152 (3)

(1) average of 149. (2) average of 114. (3) average of 75.

(1.)—*Excluding suppressed trees.* 113 *stumps.*

Length of radius ...	2·75	5·5	8·25	11·	13·	15·
No. of rings	17	34	56	86 (1)	118 (2)	151 (3)

(1) average of 112. (2) average of 101. (3) average of 74.

(2).—KAROLI FLAT. *Including suppressed trees.* 39 *stumps.*

Length of radius ...	2·75	5·5	8·25	11·	13	15·
No. of rings	12	30	62	105 (1)	122 (2)	154 (3)

(1) average of 37. (2) average of 26. (3) average of 19.

(2).—KAROLI FLAT. *Excluding suppressed trees.* 24 *stumps.*

Length of radius ...	2·75	5·5	8·25	11·	13·	15·
No. of rings	12	26	48	82	114 (1)	151 (2)

(1) average of 23. (2) average of 18.

(3).—HILL SIDES. *Including suppressed trees.* 114 *stumps.*

Length of radius ...	2·75	5·5	8·25	11·	13·	15·
No. of rings	19	40	67	103 (1)	127 (2)	151 (3)

(1) average of 112. (2) average of 88. (3) average of 56.

(3).—HILL SIDES. *Excluding suppressed trees.* 89 *stumps.*

Length of radius ...	2·75	5 5	8 25	11·	13·	15·
No. of rings	18	36	58	88 (1)	118 (2)	151 (3)

(1) average of 88. (2) average of 78. (3) average of 56.

It was not necessary to give the figures for Karoli Flat and the hill sides separately, but they are interesting, as they tend to prove that the growth of Chir is slower on the hill sides than on level ground during the first half of its life. The important point, however, was to find at what age Chir reaches a girth of 6 feet, and this, of course, depends on what age we take as the limit of suppressed trees. Including all trees, we have 104 years as the age at which the tree attains 6 feet in girth, and excluding suppressed trees, we find this girth at the age of 86 years. Carrying the analysis further, we find that 2 trees attained a girth of 6 feet between the ages of 40 and 50 years, 7 trees between 50 and 60, 17 trees between 60 and 70, 18 trees between 70 and 80, 22 trees between 80 and 90, 16 trees between 90 and 100, while the remaining 71 trees, or very nearly half the total number, required 100 years or more to reach this girth. It will be interesting to compare these figures with those obtained in the case of *Abies Webbiana*. We find that of 97 Morinda trees examined in the Deoban Forests, a girth of 6 feet was attained by 8 trees between 40 and 50 years, by 9 trees between 50 and 60, by 17 trees between 60 and 70, by 13 trees between 70 and 80, by 17 trees between 80 and 90, by 11 trees between

90 and 100, and by 22 trees at the age of 100 years or more. These results, as far as they go, prove that the growth of Chir is somewhat slower than the growth of Morinda.

Out of the 153 chir stumps examined, 58 belonged to trees which attained an age of 200 years and over, the longest lived being No. 50 with 258 years, and a mean rate of growth of 13 rings per inch of radius.

Examination of the annual rings of Pinus longifolia in the Tons Chir Forests. January and February 1879.
39 *Stumps examined on Karoli Flat.*

No. of Stump.	Rings counted on a radius of							No. of rings up to end of longest radius.	Length in inches of longest radius.	No. of rings per inch.
	2·75″	5·5″	8·25″	11·0″	13″	15″	18″			
1	11	26	50	86	148	180	...	......	......	12·
2	12	34	79	164	190	...	...	......	......	14·6
3	9	24	49	100	157	230	...	......	......	15·3
4	10	23	38	64	88	115	206	248	20¼	11·4
5	11	21	31	42	57	93	...	160	19¼	6·2
6	11	28	53	88	102	141	...	......	......	9·4
7	13	27	44	73	121	...	...	150	13¼	11 3
8	10	27	50	80	120	179	...	208	16½	12·
9	8	20	30	51	69	97	148	......	......	8 2
10	15	34	66	79	107	138	190	......	......	10 5
11	12	26	50	79	108	138	...	196	16	12·2
12	14	38	88	130	161	...	...	171	13¾	12·4
13	11	32	75	174	...	...	...	191	11¼	15·8
14	12	29	72	155	...	...	...	169	11½	14·
15	15	47	114	167	...	...	...	199	12¼	15·1
16	12	28	58	149	...	...	...	155	11½	13·5
17	12	34	72	135	...	...	...	190	13½	12·2
18	16	35	86	133	...	...	...	139	11¾	12·
19	11	22	60	139	...	...	...	182	12¾	12·6
20	19	43	85	..	...	...	...	110	9¼	11·8
21	14	45	97	...	..	...	...	132	11½	11·7
22	11	27	57	94	127	169	...	212	16½	12·8
23	11	34	76	148	...	...	...	181	13½	13·4
24	18	31	53	86	116	164	...	225	17	13·2
25	13	39	95	137	...	...	...	150	12	12·5
26	12	32	94	151	...	...	...	......	......	13·7
27	11	22	38	66	93	133	...	182	17	10·7
28	12	27	53	88	124	168	...	......	......	11·2
29	13	27	54	107	154	...	...	170	13½	12·6
30	13	24	44	81	129	...	...	176	14½	12·1
31	12	30	66	120	...	...	...	148	11¾	12·6
32	10	25	50	77	108	143	...	182	17¾	10·2
33	11	21	31	57	84	132	...	189	18	8·8
34	14	30	53	82	116	157	...	177	16	11·
35	13	33	55	87	112	165	...	232	16½	14·
36	11	22	41	77	111	...	...	197	16	8·5
37	10	23	48	91	127	175	...	223	18	11·6
38	14	41	95	142	171	203	...	213	16	13·3
39	14	29	51	106	163	...	...	......	......	12 5

Stumps on hill side within half a mile of the Tons.

No. of Stump.	Rings counted on a radius of							No. of rings up to end of longest radius.	Length in inches of longest radius.	No. of rings per inch.
	2·75″	5·5″	8·25″	11″	13″	15″	18″			
40	10	22	46	92	135	...	...	176	14½	12·1
41	14	27	62	112	176	...	...	182	13¼	13·7
42	17	51	99	147	177	...	...	......	......	13·6
43	10	25	40	63	86	160	...	199	16¼	12·2
44	24	43	63	90	119	152	215	254	19½	13·
45	24	37	53	73	95	125	214	......	......	11·9
46	27	48	78	121	179	...	...	218	14½	13·
47	21	39	59	83	105	133	193	224	19½	11·4
48	28	63	101	157	199	...	...	232	13½	17·2
49	21	42	72	114	161	201	227	237	18½	12·8
50	*16*	*41*	*83*	*118*	*143*	*184*	*241*	*258*	*18¾*	*13·7*
51	23	51	81	116	164	221	...	......	......	14·7
52	12	24	38	70	125	206	...	......	......	13·7
53	17	31	49	78	108	128	180	222	20½	10·8
54	18	36	56	89	138	193	...	198	15¼	12·9
55	24	53	124	205	...	...	...	......	......	18·6
56	20	41	68	105	130	164	...	203	16¾	12·1
57	22	40	61	85	114	162	...	178	15¾	11·3
58	19	40	61	100	138	...	...	219	18¼	12·
59	19	47	83	140	...	...	...	204	16	12·7
60	18	39	74	142	201	...	...	212	13½	15·7
61	14	30	45	69	106	180	...	205	15½	13·2
62	34	63	78	92	103	118	...	160	17¼	9·2
63	21	42	67	97	126	148	190	......	......	10·5
64	17	32	49	75	121	180	...	......	......	12·
65	20	35	51	65	75	89	121	142	18¾	7·5
66	22	45	66	102	132	190	...	196	16	12·2
67	21	32	45	62	93	...	...	184	17	10·8
68	15	30	48	76	101	149	...	169	15¾	10·7
69	19	30	43	54	62	73	99	146	21	6·9
70	21	38	59	84	111	155	...	199	16½	12·
71	15	36	62	100	150	216	...	241	16	15·
72	17	32	45	59	80	118	...	145	16½	8·7
73	22	35	50	66	84	105	...	140	16¾	8·3
74	18	34	48	67	85	107	170	......	......	9·4
75	15	34	55	89	113	...	...	157	16¾	9·3
76	20	36	61	*69*	*99*	*182*	...	......	......	12·1
77	16	37	62	90	128	...	...	177	16¼	10·8
78	17	32	47	65	84	106	143	162	19	8·5
79	17	32	50	82	119	...	...	174	17¾	9·8
80	15	40	77	147	...	...	...	159	11½	13·8
81	17	39	61	82	95	108	143	154	19	8·1
82	24	38	61	94	148	...	...	201	17½	11·4
83	27	61	120	189	...	...	...	203	13	15.6
84	20	47	77	121	167	200	...	250	17½	14·
85	17	40	69	121	201	...	...	......	......	15·5
86	18	32	49	71	104	156	...	201	18	11·1
87	22	39	52	76	101	169	...	223	17	13·1
88	32	78	134	186	216	...	...	232	14	16·5
89	29	54	80	126	176	...	...	186	13½	13·7
90	17	44	90	127	160	186	...	201	15½	13·
91	18	39	68	113	...	...	...	164	11¾	13·9

Stumps on hill side within half a mile of the Tons—(Contd.)

No. of Stump.	Rings counted on a radius of							No. of rings up to end of longest radius.	Length in inches of longest radius.	No. of rings per inch.
	2·75″	5·5″	8·25″	11″	13″	15″	18″			
92	15	30	51	91	149	...	...	214	14½	14·7
93	16	32	55	85	105	...	...	176	17	10·3
94	15	31	70	151	...	...	...	......	......	13·7
95	23	38	60	105	156	...	...	......	......	12·
96	16	32	53	94	138	...	...	171	14½	11·7
97	21	35	47	64	80	102	152	190	19	10·
98	15	27	38	60	91	...	...	156	16¼	9·6
99	15	39	58	103	...	...	...	174	15	11·6
100	14	26	44	75	116	155	...	188	16	11·7
101	*19*	*57*	*98*	*140*	...	...	...	*165*	*12*	*13·7*
102	13	31	54	157	...	..	...	230	16¾	13·7
103	26	58	102	176	...	...	...	221	11¾	18·8
104	22	41	66	87	109	169	...	234	22	10·6
105	17	34	59	90	123	190	...	196	15½	12·6
106	16	51	86	140	208	...	...	......	......	16·
107	17	33	56	97	...	...	...	136	16½	8·2
108	19	47	73	106	...	...	...	124	12¼	10·1
109	18	29	42	57	74	122	...	161	16	10·
110	13	22	30	43	57	74	130	159	19	8·3
111	14	25	39	69	...	...	...	139	14¼	9·5
112	15	26	40	59	76	93	130	159	22¼	7·1
113	23	46	73	111	...	...	...	162	15½	10·4
114	*16*	*37*	*60*	*86*	*113*	*143*	...	*159*	*15¾*	*10·*
115	14	31	49	72	103	...	...	127	14¼	8·7
116	15	34	58	94	...	...	...	128	12½	10·2
117	17	33	52	82	117	172	...	......	......	11·4
118	11	24	36	54	69	93	148	171	18¾	9·1
119	14	30	49	72	92	...	...	135	16½	8·1
120	19	36	57	80	113	151	23[illegible]	......	......	12·7
121	19	39	76	...	...	...	...	210	17	12·3
122	19	47	67	97	139	188	...	252	19	13·2
123	25	55	95	141	196	...	...	203	14	14·5
124	15	29	43	64	92	132	201	......	......	11·1
125	17	30	45	67	90	130	188	230	19¾	11·6
126	15	40	79	141	182	...	...	189	13½	14·2
127	*18*	*40*	*66*	*95*	*126*	*166*	*218*	*232*	*18½*	*12·5*
128	16	49	93	152	203	...	...	......	......	15·6
129	14	30	52	91	127	...	...	133	13½	9·8
130	15	30	48	69	83	114	...	180	17¼	10·2
131	24	59	98	135	164	...	...	209	16¾	12·4
132	16	33	54	77	...	...	...	140	15	9·3
133	23	53	89	142	...	...	...	168	12½	13·4
134	28	74	123	174	...	...	...	198	12¾	15·5
135	28	72	125	170	...	...	...	199	13½	14·7
136	35	87	153	201	...	...	...	242	14¼	17·
137	21	52	129	...	...	...	...	234	14½	16·1
138	25	53	99	171	215	...	...	257	15¾	16·3
139	22	42	74	120	162	208	...	252	17¾	14·
140	*19*	*42*	*65*	*100*	*139*	*204*	...	*230*	*18¾*	*12·2*
141	18	30	49	74	96	133	...	180	17	10·5
142	15	32	48	63	76	96	154	196	20	9·8
143	14	31	55	83	106	129	...	169	17¾	9·5

Stumps on hill side within half a mile of the Tons—(Contd.)

No. of Stump.	Rings counted on a radius of							No. of rings up to end of longest radius.	Length in inches of longest radius.	No. of rings per inch.
	2·75″	5·5″	8·25″	11″	13″	15″	18″			
144	19	38	60	110	...	...	...	158	15½	10·1
145	23	45	75	122	163	...	...	175	13½	12 5
146	22	51	79	126	173	...	...	218	15	14·
147	16	31	50	75	121	190	...	210	15¾	13 3
148	24	51	97	191	...	...	...	235	13½	17 4
149	26	57	86	123	170	...	...	193	15	12·8
150	27	70	133	165	...	...	...	232	19¼	12·
151	18	37	63	128	...	...	...	215	13¼	16·2
152	21	39	60	101	137	177	...	242	21	11·5
153	21	42	65	86	112	167	...	250	18	13·8

Experimental Consignments of Indian Woods in the London Market.

SPECIMENS of 21 different kinds of Indian woods from the Debra Dún Division, chief among which were boxwood, Toon and *Thanella* (*Gardenia turgida*) have lately been sent home for experiment from the N. W. Provinces, and the following are the remarks made on them by the timber merchants, Messrs. Churchill and Sim :—

"BOXWOOD.—The specimen has been faced in the manner usual in preparing wood for engraving, and my opinion is, that this particular example proved to be equal to Boxwood from Turkey, in fact superior to much that is obtained from thence, and has the advantage of paleness of colour, which is a feature of much value.

"A log of East India Boxwood, of about 12 feet long, was sent me in a sound state, and had cost £7, but on being divided into three pieces, had rapidly developed several rents, and had become valueless.

"Turkey Boxwood is not free from such defects, but in the best specimens only one rent forms.

"I presume you are aware that engraving is effected on horizontal sections of the tree. For this purpose, sections are sawn slightly over one inch thick, which are then placed in racks, and kept in a regulated temperature for some years.

"A wood block, such as you see in the illustrated papers, is built up of selected pieces, about 3 inches by 2 inches, which are separately worked upon, and afterwards combined into one by special forms of bolts and nuts. These blocks, I may observe, are not ordinarily used in printing, the ultimate printing surface being obtained by means of the electrotype.

"Most hard woods are denser on one side than the other, and in the special example of Boxwood, the subject of this letter, a portion about 3 by 2 inches would only be used for the best work, and the remainder applied to blocks of lesser value.

"The manufacturer of wood blocks is said to pay three times more than the ordinary current value for the wood he selects. There is at this time much complaint, both by manufacturers and engravers, of the scarcity of fine material. This is in part attributed to wood growing in certain Russian forests being withheld from sale.

"I think it probable that the rendering of the logs may be in some degree lessened by attention to the period of cutting. Upon the indifference in colonies to the time of felling some excellent observations have been made by Mr. More, Director of the Botanic Gardens at Sydney, which may almost be summed up in his own words: "It would appear that the best time to cut down trees, in order to secure the most enduring timber, is either immediately after the fall of the leaf of those that are deciduous, *or shortly after the seed has ripened into maturity in those that are of an evergreen character*."

"No. 18 (*Gardenia turgida*) appears to be of good close-grained quality, and the specimen shows no indication of splitting. We think it would be found saleable as a substitute for cheap Boxwood, and should like to see a larger specimen of this wood, in order to have its value tested, and therefore recommend that a log of about 12 inches square and about 10 feet long be sent for this purpose.

"The most promising specimen is No. 11 (*Cedrela Toona*), of which we have a good opinion, and consider that it would prove saleable as a substitute for Mahogany; and if sent in well-squared (hewn and not sawn) logs, 15 inches and upwards square and 12 feet and upwards in length, it would probably command from 2*s*. 6*d*. to 3*s*. per foot cube; but a trial shipment of 10 to 12 logs as large, long, sound and straight as possible would be advisable before sending larger quantities."

The other woods sent were reported not to be of a character fit for the Cabinet trade, chiefly on account of their hardness and lack of any special merit. We are rather surprised, however, that Sain, Sandan, Mohwa, Sissu, Khair and Siris were not noticed, as we should have thought some of them might have been rather better reported on.

On some Woods and Wood products in common use in Japan.

From the Timber Trades Journal.

(*Continued from Vol. V., p.* 467).

Building Woods.—Resinous woods and bamboos are the woods most commonly used in Japanese structures. Pines (*P. Massoniana, densiflora, parviflora, Koraiensis*), firs (*Abies firma, tsuga, alcoquiana, Veitchii, polita, Isoensis*), retinosporas (*R. obtusa, pisifera*), *Cryptomeria Japonica, Larix leptolepis Thuja dolabrata*, &c., abound on light soils. On heavier soils oaks, chestnuts, and other foliage trees are plentiful. Dr. Savatier has enumerated eighteen deciduous and evergreen species of oak found in Japan, besides four which he regards as mere varieties and five others as yet indeterminate. But the difficulties of transit, and the need of light structures in a country where earthquakes are so common as in Japan, have caused heavier woods to be restricted to specific objects, and preference to be given to resinous woods, even for such ineligible purposes as bridge building and railway sleepers. And of all resinous woods, hinoki, the wood of *Retinospora obtusa* enjoys the highest repute. The tree, which grows with amazing rapidity and vigour, is held sacred in the Shinto religion. In most of the temples, and in the palace of the Mikado, hinoki has been used almost exclusively both for the structure and the furniture. It is generally employed unvarnished. It gives a beautifully white even grain under the plane, and is said to withstand damp perfectly. It is soft enough to take the impression of the finger nail. Sawara, the wood of *Retinospora pisifera*, is used for like purposes, but is less esteemed.

The costliest roofs are formed of frames of hinoki, overlaid with thin strips of the same wood, each strip being eight inches long, 2 inches broad and two-tenth's inches thick, and very carefully planed, laid side by side with their long sides at right angles to the eaves. They are treenailed to the laths beneath, each course overlapping the one next below it some six inches or more. A very high pitch is needed, and much material and labour are requisite, but the arrangement lends itself to the production of the most fanciful and complex curves. With a sufficient pitch these roofs are perfectly water-tight, and some are said to be over a hundred years old. The residences of the high officials and many Buddhist temples are laid with flat tiles set in cement on a surface formed of yane-ita or small laths, one-tenth inch in thickness, laid close together. The best of these yane-ita are made of retinospora; the worst of split green bamboo. Poorer dwellings are roofed with split bamboos laid ridge and furrow, like tiles, or with wooden shingles fastened to the rafters with bamboo treenails, or with bark, thatch, or paper. Gutters are formed with split bamboos.

Woods for Paper-making.—The coarsest papers are manufactured from the bark of *Edgeworthia papyrifera,* called Milsoumata (or three-pronged fork), owing to the shoots appearing symmetrically in triplets It forms a shrub growing about five feet high, and is cut down level with the ground year after year until it gives a sufficiently bushy head for stripping. Good paper is also made from Kozou, *i.e.,* the bark of the paper-mulberry (*Broussonetia papyrifera*), which is cultivated for paper-making all over Japan. The plantations are said to average about a ton of bark to the English acre annually, which is, however, believed to be a very exaggerated estimate. The fineness and toughness of this paper allow it to be used for a variety of purposes unknown in Europe, such as substitutes for window glass, in which ornamental effects may be produced by using papers of different degrees of transparency, bandages for wounds, pocket handkerchiefs, twine and thread of all sizes, &c., &c. By passing the wove-mould a second time through the pulp so as to cross the grain, a stouter paper is obtained, used for covering umbrellas, trunks, &c. The magnificent *leather paper,* with or without embossed patterns, the manufacture of which is still a profound secret, is made from Kozou. A sort of tissue paper of great strength and marvellous fineness and softness of texture, weighing only half a pound avoirdupois per 100 sheets of 19 inches by 14 inches, is made from the bark of a shrub called gampi, which appears to be *Lychnis grandiflora,* and has a fine-grained mucilaginous bark. Another paper of extraordinary strength, which figured in the last Paris Exhibition, is manufactured from some unknown material. For common papers, rice-straw, young shoots of bamboos and other substances are mixed with the pulp. Japanese papers are not generally sized, but when done it is with a mucilage obtained from the bark of a shrub called ouri (*Marlea japonica*?). Sized papers are coming into more common use, being better adapted than others to printing in European type. In the mountains, shavings of retinospora are used as a substitute for paper.

Lacquers and Varnishes.—These are all made with a resinous base extracted from ourouchi (*Rhus vernicifera*), which is not to be confounded with the so-called Japanese varnish of Europe. There are eight kinds of lacquers, some colourless, others coloured, each made by separate makers and by processes which yet remain secret. The resisting powers of these lacquers appear to increase with age, in confirmation of which it is stated that when the mail steamer conveying exhibits for the Vienna Exhibition of 1873 was wrecked off Cape Idsou, the cargo laid for fifteen months in ten fathoms of water, and when recovered by divers the antique articles in black lacquer were found uninjured, while those of recent manufacture were completely ruined.

Dyes and Tan Stuffs.—Yellow dyes are obtained from the barks of hadjinoki, dzoumi (a variety of *Pyrus*), koutinachi (*Gardenia florida*), kiwada (*Evodia glauca*), and inoukwada. According to a native writer the bark of *Evodia glauca* is the true kiwada, as giving the finest colour, though the name, signifying literally "yellow skin," is applied to others. Yellow dyes are also extracted from the flowers of *Sophora japonica* and *Sapindus moukourodji*. Red dyes are obtained from safflower, several native species of madder, and red dye-woods imported from China. A fine claret is produced by digesting alder bark in an infusion of the fruit of the m'me or plum apricot. Blue is extracted from *Polygonum tinctorium*; browns and greys are produced with myrtle and mulberry barks, the fruit of *Rhus semialata*, the bark of *Retinospora obtusa*, &c. Blacks are produced with the help of sulphate of iron, with the barks of various oaks, the bark and fruit of two species of alder, the fruit of *Diospyros Kaki*, of the Japanese chestnut, various galls, notably those found on *Quercus serrata* and the pounded nuts of *Juglans mandshurica*. Some of these substances are used in tanning, more especially the barks of *Quercus dentata* and *Myrica rubra*, which are in great demand among Japanese fishermen for tanning their nets. The fruit of the chiboukaki (a variety of kaki) pounded in water containing lamp-black, gives a black which at a distance resembles oil-paint, and is used in colouring fences and house fronts. It requires renewing every two or three years.

Water Conduits are generally made of bamboo, split or otherwise. Where a larger service is requisite, conduits of square section and formed of some resinous wood are used. Those supplying the city of Tokio are said to have been laid over a century. They are not watertight, and allow of a considerable waste of water.

Porter's Poles.—For heavy loads the stiffest poles, as kachi (evergreen oak), kaya (*Torreya nucifera*); for medium loads, segni (*Cryptomeria Japonica*), moukou, a species of elm and hinoki or retinospora; for light burthens, yenzou *Sophora Japonica*) and bamboo are used. The usual load is 48 lbs. at a run, and 100 lbs. at a walk; distance four leagues, including return empty. At piecework, loads up to 1½ cwt. are thus carried.

Sundries.—Oils for cooking are extracted from the fruit of *Torreya nucifera*, *Juglans mandshurica*, and two kinds of camellia; oils for illumination from *Eleococca verrucosa*, the camphor tree and the seeds of the tea shrub; oils for the toilette from ivy berries, and the fruit of *Taxus cuspidata*. Birdlime is manufactured on an immense scale, and of great strength, from the bark of *Ilex integra*. The yield is 2 lbs. of birdlime to 20 lbs. of bark. Amongst other purposes it is employed in catching waterfowl, for which purpose it is spread on bamboo rafts. It

is also used in medicine, externally and internally. The trunks of oaks are largely utilized in growing edible mushrooms. The trees are felled and split in the woods, and left to decay, when they serve as beds for the growth of mushrooms of various kinds, which are afterwards dried for use or export. From six to nine per cent. of the weight of the timber felled is, it is said, thus returned in the shape of mushrooms, which, in view of the difficulties of transport, is found to be a more profitable arrangement than attempting to turn the timber to account in other ways. The export of dried mushrooms from Japan to Chinese ports during the year 1876 was valued at £50,000 sterling.

Note on the Artificial Cultivation of Cedrus Deodara.

By A. Smythies.

The following brief notes apply to the experience hitherto gained in raising young plants of Deodar from seed in the forests of Jaunsar-Bawar, North-West Himalaya.

The object of the operations carried out in Jaunsar is to increase the quantity of Deodar in forests chiefly consisting of Fir and Oak, but principally to re-stock bare grassy slopes. Two different systems are employed; 1st, sowing the seed directly on bare slopes; 2nd, raising young plants in a nursery and transplanting them.

I.—Direct Sowing.—This is effected by sowing the seed in prepared holes or patches along the hill side. The patches are about one foot in diameter, and three or four feet apart, and follow contour lines as nearly as possible. It is not important that they should be at very regular distances apart in the lines, and advantage is taken of any shelter, such as small shrubs and rocks, near or under which the holes are dug; but each line should be almost horizontal. The lines are 15, 20, 25, or 30 feet apart, according to circumstances, being closer together where the slopes to be restocked are very bare, exposed, and far from trees, and further apart where there are already a few young plants, natural seedlings on the ground, or where seed shed naturally from neighbouring trees may lead us to expect seedlings in the course of a few years. The soil in each hole is thoroughly dug, sifted with the hand, and freed from grass and stones, and in November and December, as soon after the seed falls as possible, the holes are sown up, 12 or 15 seeds being scattered over the patch, and lightly covered with soil. The seeds germinate in March and April, not long after the snow has melted and the days begin to get warmer.

Our present experience proves that seed sown before the winter will do much better than seed sown in the early spring; germination is more plentiful, and the young plants are much

stronger and more capable of enduring the heat of the summer and, similarly, slopes with southerly aspect.

There is little to be said regarding the after-treatment of the young plants, firstly, because they require very little tending; and, secondly, because our experience is too recent to enable us to lay down rules on the subject. In a very hot summer it may be advisable to cover the patches with grass shades, or better still with small fir branches, and if the grass in the rainy season shows signs of choking the plants, it may be cut away round each patch; but neither the one operation nor the other is insisted upon, as it is not decided yet whether either is really necessary. Many seedlings dry up in the heat, and some patches will turn out blank; but this would probably happen in spite of all precautions. The aspect, the season, the soil, the seed—all are factors in the problem, whether the young plants live or not, and no fixed rule can at present be laid down.

Many of the young seedlings in April and May are cut down by one or more species of grub, and some patches have been entirely destroyed. The fact was noticed last year (for the first time I believe), and this year we have captured some of these grubs, and endeavours will be made to rear them, and see what the insect turns out to be.

The seeds of the Deodar should be full of transparent liquid resin, should show the first bundle of leaves in the centre, yellowish green, and should run about 3,500 to a pound Avoirdupois.

II.—NURSERY PLANTS.—Seed and nursery beds are prepared in a garden situated almost in the middle of the scene of operations. The seed beds are ordinary garden beds about four feet wide, and the seed is sown pretty thickly in lines 12 inches apart, in November and December. The young plant in the following rains are bedded out into nursery beds. These beds are about four feet broad, and of various lengths, according to circumstances. Good soil is prepared, and heaped up about three inches deep on a hard bottom, which consists of limestone gravel well beaten down. The object of this is to prevent the formation of a long tap-root, induce the growth of bushy roots, and thus render the work of transplanting easier, less costly, and surer in results. The young plants are put out into these beds in lines 12 inches apart, at intervals of 3 inches apart in the lines.

They are covered with light grass shades or mats during the frosts of the early winter, but the mats are removed when snow falls. In the hot weather they are covered up again, and are occasionally watered. The seedlings remain two whole years or more in the beds, and are finally put out into the forest in July, as soon as the rains have well set in. Regarding the age at which they should be put out, we have not much

experience to guide us. Plants five years old (from seed) were put out in July 1879, and up to date are for the most part doing well, but they had long tap roots, which were cut off in every instance at about 18 inches to 2 feet from the crown of the root; the crucial time for these is only just beginning, and if they survive one hot weather, the presumption is, that they are safe. In my opinion, however, it would be better to put them out in the forest younger, at two or three years old, or four at the outside. The distances at which they should be planted out depends entirely on the object in view. 10′ × 10′ has been generally adopted in open places.

The old plants mentioned above were dug out with as much soil as would adhere to the roots, were wrapped round with grass, and carried in baskets to the scene of operations. I am not prepared to say that these precautions are necessary, and when we raise plants with short bushy roots, and put them out young, it may possibly be found that no soil or grass is necessary, and that they will be entirely freed from soil in the nursery, and then taken away, and put out with as little delay as possible. When dealing with large areas, a cheap and effective process must be adopted, and it is to be hoped that the system of direct sowing will be successful, and that putting out nursery plants will only be its complement. It is not feasible at present to give the relative cost of these two systems, but it may safely be said that the first one—that of direct sowing—does not cost more than Rs. 5, (about 10 shillings) per acre; any failures involving re-sowing would, of course, increase this figure. The second is much more expensive, involving, as it does, protection of the nursery plants for at least two years and a half.

Memorandum on the Forests of the Kuram Assigned District.

BY C. BAGSHAWE, *Deputy Conservator of Forests.*

Division of forest area.

1. For purposes of description the forests of the Kuram District may be divided as follows :—

(*a*).—The Hazár-Darakht forests, extending from Ali Kheyl to the Sirkai Kotal, and lying on both right and left banks of the Hazár-Darakht river.

(*b*).—The Hariáb forests, to the north of the river of that name, and between Mounts Matunga and Sika Rám.

(*c*).—The Peiwar and Mangiár forests, lying on the east and north-west slopes of the range running from Sika Rám, on which Peiwar and Mangiár are well known points.

(*d*).—The Kuram forests lying on the southern slopes of the main range between Sika Rám and Karama peaks.

Hazár-Darakht Forests.

2. The Hazár-Darakht forests are nearly pure deodar. A few juniper (*J. excelsa*) and spruce (*A. Smithiana*) are found in the valleys, and some silver fir (*A. Webbiana*) high up on the ridges and in gorges with a northerly aspect, but deodar forms 90 per cent. of the entire crop.

The forest near the Sirkai Kotal and for several miles down stream have been heavily worked for the supply of the Amir of Afghanistan's works at Kabul, whither the wood was apparently conveyed on camels by forced labour.

No export appears to have taken place from the Hazár-Darakht forests to the plains of India, and the shallow rocky nature of the river seems to forbid floating even during the flood season of March and April. These forests have suffered little from the actions of the villagers. Above and below Rokia cultivation has driven the forest back from the level ground, the trees have been lopped for fuel, and light fellings of poles been made for household purposes. In the Hazár-Darakht forests, as in the Kuram District forests generally, the absence of all under-growth either of shrubs or grass is very marked; fires are consequently of rare occurrence, and are the cause of little damage to the trees: the poorness of the grazing, however, leads to the destruction of much young growth of deodar by sheep and goats.

Owing to grazing, &c., the reproduction in open parts of these forests appears to be in an unsatisfactory state, but information on the point is scanty owing to many parts having been unexplored.

Hariáb Forests.

3. The Hariáb forests consist of deodar, Gerard's pine (*P. Gerardiana*) and blue pine (*P. excelsa*) with a few spruce and silver fir, juniper forming a kind of scrubby bush. Deodar appears to form 70 per cent. of the entire crop, and for some miles to the north-east of Matunga, and from that hill towards Ali Kheyl the forest is fairly compact and the cover complete, an exception to the rule being some large grassy plateaux in the centre of the forest to the west of Belut.

Should the Kuram river prove one fit for floating sawn timber, these forests may in the remote future yield timber for export to other districts, but their distance from that stream giving a mean land carriage of about ten miles must always prove a great drawback in their value.

The villagers' demand for timber is not large, as they use flat mud roofs, and only want posts, rafters, doors, &c.

In the vicinity of openings in the forest, where grass is found in small quantities, the trees suffer a little from fire, but,

as in other parts, grazing is the greatest enemy the trees have; and in the Hariáb the exclusion of grazing is the first preliminary to working the forests.

The villagers have a lazy way of collecting fuel, *viz.*, by lopping branches, and the outer fringe of forest looks very ragged in consequence. It is remarkable what a short distance the villagers go for fuel, and the small quantity that satisfies them; this may, however, be accounted for by the fact of the upper portion of the Hariáb being abandoned during the winter, owing to the intense cold and a short food-supply, which, I understand, make the inhabitants migrate annually to more genial climes. I have been unable to find out much about the seed of Gerard's pine, at what period it seeds, or what the people do with the crop. It certainly is not in seed generally this year, and none of last year's seed is brought for sale, so I presume that was a non seed year too. In seed years it must be produced in large quantities, and might be made a source of forest revenue by direct collection or the imposition of a tax.

Peiwar and Mangiár Forests.

4. The Peiwar and Mangiár forests form, in my opinion, the most important of the three deodar forests of the Kuram; the block is large, compact, and separated from our own villages. The demands for grazing, fuel and timber, are chiefly made by non-inhabitants, who, the Political Officer tells me, have probably no rights therein. As soon, therefore, as these adjacent tribes are disarmed, and taught to respect English rule, the introduction of forest management by the Forest Department may, should financial considerations permit it, be feasible.

The Peiwar and Mangiár forests may be described as lying on the eastern and western slopes of the Peiwar range, and extend from the Spingawai Pass (or Kotal) to the Mangiár peak; beyond this peak is Mangal territory, and the forests are unexplored.

Along the ridge we find nearly pure deodar until you approach the Mangiár peak, where you get into fir and yellow oak (*Q. semecarpifolia*); and finally getting beyond the limits of forest you reach a bare hill top.

On the eastern slope of the range, after passing through some precipitous ground sparely covered with deodar, holm oak, blue pine, and juniper, you get on to easier slopes fairly covered with holm oak. High up on the hill side, and in unfrequented gorges, we find this tree growing well, and attaining a girth of 7 feet, and a height of 40 to 50 feet; but lower down and near the road and villages it has been steadily pollarded, and forms a scrub about 12 to 15 feet high. I have not succeeded in ascertaining the rate of growth of the holm oak; the annual rings are very indistinct, and I had no instrument for cutting microscopical sections.

It will probably be found that the only methods of working this particular holm oak forest are, either by regular cuttings in coppice, or by pollarding; probably the latter, as it would be most difficult to close any large part of it for any considerable period, so as to permit the coppice shoots to attain a height of say 7 feet, and so be safe from grazing. This part of the Peiwar forest can only be made useful in meeting the Shalozan fuel demand, and as it is very probable the forests to the north of Shalozan will suffice for this, the forest may be one of those left entirely for villagers.

The western slope of the Peiwar range has a fall of 1,300 feet in ten miles, giving an average gradient of about 1 in 40; the ground is broken up by small gorges and ridges branching out from two main spurs running to Bain Kheyl and Ali Kheyl, the violent action of torrents of melted snow being very marked. Between Ali Kheyl and Mangiár are some extensive grassy plateaux generally bare of trees, and there is a similar plateau close to the Spingawai Pass; the area of the latter, known as the "Sonamurg," cannot be less than 400 acres.

Along the Peiwar range, and for at least 2½ miles to the east, the forest crop consists of deodar, spruce and silver fir, holm oak, blue pine, and juniper; deodar, I think, forms 80 per cent. of the entire crop; in many places it is 95 per cent., but the general average is reduced by some gorges being filled with silver fir. Further west and down to Ali Kheyl, deodar, Gerard's pine, juniper and a few holm oak form the forest, deodar still standing at about 80 per cent. of the whole.

Throughout these forests the bare brown ground, and the almost entire absence of undergrowth, is a very marked feature, comparable to nothing I have seen in Himalayan forests. Cotoneaster willow, a viburnum, two roses, with some balsams and daphnes, are nearly all the shrubs and undergrowth found, and they have to be sought for.

I have been unable to make any exact examination of these deodar forests, save in the vicinity of the Peiwar Kotal; the results of my observations I append to this memorandum for reference.

The areas I examined are, I think, fair examples, as far as deodar goes, of about half the forest area between Peiwar Kotal, Mangiár and Ali Kheyl, and I think we may put the crop of deodar from 2 feet girth and upwards at 50 trees per acre. Assuming the area at 16,000 acres, this would, deducting 8,000 acres for other classes of forest blanks and precipices, give 8,000 acres at 50 trees per acre, or 400,000 deodar trees. Of these about 17 per acre are first class trees, which gives a reserve of 136,000 trees, average height 100 feet, average girth 7 feet, probable yield in wrought timber 56 cubic feet per tree. The average age of a six-foot tree is 237 years, say

240; and it takes a 4 feet 6 inches girth tree about 60 years to become of first class size. We might apparently, therefore, expect these forests to afford an annual yield of 2,200 trees, or, say, 23,200 cubic feet of wrought timber equal to 35,200 broad gauge sleepers.

These figures are of course but guesses. I believe, however, they convey a fairly accurate idea of the deodar resources of the Peiwar-Mangiár deodar forest.

Kuram Forests.

5. The Kuram forests form a belt along the southern face of the Safed Koh, between Sika Rám and Karama peaks, varying in width from one to five miles, and in elevation from 7 to 11,000 feet.

The forest crop consists of holm oak at from 7,000 to 7,500 feet. Above this, we find it mixed with spruce and silver fir and blue pine. At about 8,000 feet the holm oak decreases, *and its place is taken by the yellow oak, and this mixture is* found to about 10,000 feet, where the crop is nearly pure silver fir and rhododendron. Deodar is only found in the Spingawai gorge to the extreme west, where a few moss-grown trees are scattered about in precipitous ground.

This forest is naturally divided by ridges into six large blocks, all of which can easily be worked for fuel by mule roads up the gorges, similar to one already made up the Shen Toi to the north-east of the Shalozan cantonment.

The lower parts of these forests are a good deal worked by the villagers for fuel, and as usual they lop branches instead of cutting up large wood. A little temporary cultivation had at times sprung up, but Shinwari raids have apparently tended to stop it.

There is a good deal more balsam and daphne to be seen in these gorges than on the Peiwar range, but the absence of undergrowth is still very marked.

The villagers appear to graze these gorges lightly, and I understand they also allow migratory tribes to graze here in the hot season, when the valleys are unhealthy. On the lower slopes of the hills there is a little grass, which is burnt annually; the fire, however, does not appear to spread into the forest.

Forest requirements of the villagers.

6. In the course of describing the different forests I have alluded to the villagers' forest requirements. They may be noted as—

(*a*).—Bullies and small timber for building, each village using the coniferous wood nearest to hand, and not being prejudiced in favour of deodar.

(*b*).—Fuel, which they take in the form of branches.

(*c*).—Leaves for fodder and ground for grazing.

As a rule, they have done wonderfully little damage to the forest in supplying their wants, and the fact has been noticed by many besides myself.

To provide for the wants of the actual inhabitants would in any other part of India be an easy task, and leave large areas of forests unburdened by rights. Here a settlement is complicated by the lawless nature of the people, and by the fact that an unknown number of outsiders have grazed, and cut in these forests without let or hindrance.

In the opinion of the Political Officer at Kuram it will be most unadvisable for years to interfere in the exercise of forest rights beyond putting down the most objectionable practices through the headmen (Maliks) of villages, and clearly making the villagers understand that the forests are not theirs. It therefore is needless, I think, for me to dwell on the definition of forest rights and subsequent assignment of forest reserves.

Local requirements of Government.

We now come to the local requirements of Government from these forests. So little has been decided as to the method to be adopted for holding the Kuram that these wants are very indefinite. I am led to believe, however, that for some years they will not exceed—

(*a*).—12,000 cubic feet of wrought deodar timber per annum.

(*b*).—120,000 maunds. of fuel per annum.

These supplies are required partly at the Peiwar Kotal or its equivalent, at Ali Kheyl, at Shalozan or its equivalent, and at Kuram. Fortunately in one way, unfortunately in another, the demand can be easily met.

The extensive fellings made for military purposes near the Peiwar Kotal along the ridge towards Mangiàr, and dry wood within a two-mile radius of the Peiwar Kotal, will, I am sure, yield at least a lakh of cubic feet of wrought timber; in fact, measurements made to act as a guide give 1½ lakhs as the quantity. We may safely say that the demand for timber is provided for about eight years, or for four years, should it be doubled.

With regard to the fuel demand, the six gorges in the forests to the north of Shalozan (which I have called the Kuram forest) are simply filled with dry trees, the apparent accumulation of ages; they are so blocked up that in some cases the villagers use the ridges as lines of communication. In addition to the wood in the gorges, which was carried thither by the snow, there is standing or fallen dry wood in the forest. At a very low estimate, I am sure dry fuel will yield nine lakhs of maunds, or say, seven years' supply. The fuel demand figure is not, I believe, liable to increase.

The last point to be considered with regard to local demands is how the Government timber and fuel demand is to be

met eight years hence. This question cannot be answered until it has been decided how the forest rights of villagers are to be met, and what areas can be preserved from grazing.

As far as the deodar timber goes, its equivalent, some 250 trees per annum, might be judiciously felled for a century without much damage; but I do not think this idea applies to the fuel demand, and most of the "Kuram Forest" must be closed before fellings equal to the demand can be made.

Export of timber to other districts.

7. It now remains for me to consider the question of exporting deodar from the Kuram to other districts. I have previously noted that the Hazár-Darakht river is not fit for floating timber, nor is the Hariáb (or Kariah as it *is also called). Of the Kuram river I cannot speak from* personal knowledge save from Thul to Kuram. This part of the river is good for floating scantlings in the flood season; and below Thul (in Waziri territory) the river must be good to where it reaches Bannu and thence onwards to the Indus. The unknown water is from Kuram to Ali Kheyl. An obstruction is reported between Chapri and Karkai, but as the natives have certainly floated axed scantlings from Ali Kheyl to Bannu, there is little doubt that the river can be used for floating, and the question of down-country communication as far as water is concerned, may be taken as favourably settled.

The next point for consideration is the unsettled state of the country; this will apparently for some time preclude any extensive working in the forest, or on the river, as large working parties with escorts are not to be thought of. No forest work can possibly pay as long as workmen go in peril of their lives, for labor would under these circumstances be expensive and difficult to import.

The last and most important question is what closed forests *we are to have, for until a given area has been closed at least* one year, until fairly correct valuation surveys have been made of this closed area, and a plan of operation drawn up and approved, it will be destroying the forest to fell heavily, it will impoverish it to fell lightly, and the latter plan will, for obvious reasons, be financially a failure.

Granted security for life, closed forests, and ample authority for the Forest Department, I do not believe that timber from the most easily worked forest (Peiwar and Mangiár) can be exported at a profit. The long leads to the river, the difficulties in providing mechanical aids, the enormous rate of wages and the absence of competition preclude for a long time the idea of cheap labor, so that for many years it is pro-

bable 10 feet deodar sleepers could not be placed on the Indus at Kushyalgarh for less than Rs. 5 each.

8. The last point requiring attention in this memorandum is the present work of the Forest Department in this valley. Immediate heavy felling by departmental agency being inexpedient, the following is the only work left:—

Forest work in the Kuram Valley.

(a).—The prevention of further destruction of the forest, save for strictly military reasons;

(b).—As soon as the Political Officers have decided to close any large forest area, and permit such area to be freely traversed, the examination in detail of the area with the view of ascertaining its value and the possibility of working it at a profit;

(c).—If, as may probably be the case, it be only possible for some time to carry out (a), the Forest Officer might supervise the small timber works for the supply of barrack timber.

The work sketched out requires no large or costly forest establishment: a junior Forest Officer, with one Ranger, one Forester and six Guards could easily carry it on. I would strongly advise his being placed under the orders of the Chief Engineer Officer, with directions to refer through him purely professional questions for the orders of the Inspector-General of Forests.

9. Reference has been made about the possibility of profitably erecting saw-mills in the Peiwar Kotal forests. There is one stream with sufficient water for a small mill, but it would not pay owing to the cost of shifting logs to it. The only saw-mill that would pay is, I think, one or more circular saw benches worked by a portable engine; these would cut up planks, shingles, &c., for barracks, and could be moved to the logs.

Saw-mills at Peiwar.

10. In closing this report, I would again invite attention to the marked absence of grass and undergrowth both within and outside the forest. From a forest point of view, this complicates the working of the forests by rendering the hill side more liable to wash from melting snow. From a military point of view it is very serious as complicating the supply of forage.

Scarcity of grass in the Kuram Forests.

(Signed) C. Bagshawe,

Depy. Conservator of Forests on special duty.

Note.—I would beg to record the great obligations I am under to Surgeons-Major Aitchison and Fleming for information afforded me regarding forests I was unable to visit personally, and through which they had botanised.

(Sd.) C. B.

Description of sample areas under forest examined at and near Peiwar Kotal.

I.

Area and locality.

Area two acres; forms part of the cemetery ravine below, and to the east of the "Block-house" picquet. Elevation about 8,600 feet.

Configuration, gradient and aspect.

The ground is undulating; average gradient 15°.

There is no cut water-course at the bottom of the ravine, but in some places there are hollows formed by the percolation of the snow water. The ravine is sheltered, and snow probably lies late. The aspect is south-east.

Rock and soil.

Rock lime-stone, soil clay-loam, with a deep layer of vegetable mould.

Stock.

In the sample area the crop is pure deodar, in other parts of the ravine a few holm oak are found, forming about 1-50th of the entire crop. There is very little undergrowth, a poisonous grass growing in tufts, and a few balsam and viburnum being all we find. In the vicinity reproduction of deodar is good in patches that have for some time been exposed to the light; the seedlings vary in age from two to about thirty years, and have mostly suffered from grazing during *the present year*. Fire has apparently never passed through the forest, but many trees have had patches of bark removed by the villagers.

Enumeration of deodar trees.

The enumeration and girth measurements made gave the following results:—

Standing green deodar.			Deodar stumps.			Total crop deodar.			Remarks.
2 ft. to 4 ft. 6 in.	4 ft. 6 in. to 6 ft.	Above 6 ft.	2 ft. to 4 ft. 6 in.	4 ft. 6 in. to 6 ft.	Above 6 ft.	2 ft. to 4 ft. 6 in.	4 ft. 6 in. to 6 ft.	Above 6 ft.	
5	14	24	61	16	2	66	30	26	Stumps and trees measured about three feet from ground. Stumps all new ones.

There are few deodar below 2 feet girth in or near the area measured. An estimate of the height of the deodar here may be formed from the following measurements:—

1. *Girth* 10 *feet* 9 *inches*; *height* 115 *feet.*	}	Average, 11[illegible] feet.
2. " 10 " 3 " " 113 "		
3. " 9 " 5 " " 106 "		
4. " 10 " 6 " " 127 "		
5. " 12 " 2 " " 103 "		

Rate of growth.

Trying to ascertain the rate of growth of deodar in these forests was very difficult, owing to the large number of rings per inch, and I had to adopt the plan of getting the tops of stumps cut off, and a selected plane or sloping *line* smoothed with a plane before I could, with any accuracy, count the annual rings: even then I was often in doubt, and the following must only be taken as approximately correct:—

Number.	Approximate girth in inches of *stump* about 3 ft. 1 in. from ground.	Radius counted in inches.	RINGS COUNTED ON RADIUS.					Total number of rings counted.	Average per inch *per tree*.	Average per inch for locality.	REMARKS.
			0 in. to 4 inches.	4 in. to 6 in.	6 in. to 9 in.	9 in. to 12 in.	Above 12 in.				
1	51	8	118	51	54*	...	...	223	27·87	25·46	*No. rings in 2 inches—1 inch, &c.—*Vide* radius. Larger stumps not available.
2	45	7	95	54	31*	...	...	180	25·71		
3	63	10	90	37	45	13*	...	185	18·50		
4	44	6·75	121	39	12	...	...	172	25·48		
5	45	7	141	35	17*	...	...	193	27·57		
6	42	6·25	97	37	9*	...	...	193	30·88		

The girths were taken over the bark, the *average thickness* of deodar bark in the Peiwar forest being about ·66 of an inch. The *girths* are approximate only, as in some cases the stumps were chipped or broken. Twenty years have been allowed for *the growth of a deodar to three feet from the ground,* and that number has been added to the number of rings actually counted in the first four inches of radius. I arrived at this figure after counting the rings in a good many saplings, when I found unsuppressed and undamaged specimens *took from* 20 to 25 years to attain a height of 3 to 4 feet.

Summary.

The previous observations may be summarised as follows:—

The deodar crop on a south-east slope was found to be—

(*a*).—60 trees of all classes per acre.

(*b*).—Average height of 1st class trees 113 feet.

(*c*).—Assuming the average growth per inch to be 25·46 *annual rings,* the average age of a 6-feet tree appears to be 290 years.

The latter figure is founded on so few data that I only regard it as a guess, and as one that makes the average growth slower than it really is. Slow growth in this ravine may be accounted for by the snow lying late and dryness at other seasons owing to the aspect.

General.

The fellings in this and other places near the Kotal were made last winter for military reasons, and no further remark on the subject is necessary here or in other parts of this memo.

II.

Area and locality.

Area two acres, which are near the Kotal, and to the south of the Kotal and Ali Kheyl road. Elevation about 8,500 feet.

Configuration, gradient and aspect.

Unbroken slopes with no rock appearing on surface. Gradient 20°. Aspect east to north-east.

Rock and soil.

Limestone is found in the vicinity. Soil deep clay, with much vegetable mould.

Stock.

In the sample area pure deodar, saving the presence of two or three holm oak and a juniper; in the vicinity there are about three spruce fir to be seen in as many acres of forest. There may be said to be no undergrowth, a few unhealthy viburnum and balsam being all we find; grass is entirely absent. There is no reproduction to be seen; *this is probably due in part to the unfavorable* aspect, in part of the main road of the country being so close at hand, which animals would graze along, and thus prevent the germination of seed. The forest has not suffered from fire, but some trees have been barked by villagers.

The valuation survey gave the following results :—

Enumeration of Deodar.

Green Deodar.			Deodar Stumps.			Total Crop.			Remarks.
2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	
5	31	44	43	27	18	48	58	62	A few stumps are *old.*

The following heights were taken :—

1. Girth 12 feet 8 inches;	height 73 feet	} 80 feet average.
2. „ 6 „ 2 „	„ 89 „	
3. „ 9 „ 1 „	„ 82 „	
4. „ 7 „ 0 „	„ 86 „	
5. „ 8 „ 7 „	„ 70 „	

The growth of deodar in this aspect may be judged by the following:—

Number.	Approximate girth in inches at 3 feet.	Mean radius in inches.	Rings counted on radius.					Total number of rings.	Average number per inch per tree.	Average number per locality per inch.	Remarks.
			0 inch to 4 inches.	4 inches to 6 inches.	6 inches to 9 inches.	9 inches to 12 inches.	Above 12 inches.				
1	58	925	78	39	75	6*	...	198	21·40	20·30	See remarks and notes in memo. on area I.
2	87	14	58	38	68	44	25*	283	16·64		
3	57	9	88	56	76	...	...	220	24·44		
4	48	7·50	64	50	38*	...	...	152	20·26		
5	65	10	76	32	62	17*	...	187	18·70		* No. rings in 25—2 inches, 1·50 inches, &c.—vide radius.
6	66	10·50	83	49	56	3J*	...	218	20·76		
7	65	10·25	67	37	56	11*	...	171	16·68		
8	67	10 75	111	22	23	26*	...	182	16·93		
9	65	10	95	21	32	10*	...	158	15·80		
10	62	9·75	73	66	65	29*	...	233	23·89		
11	49	7 75	65	63	59*	...	...	177	22·83		
12	50	7·75	58	52	95*	...	...	205	26 45		
13	46	7·25	75	63	58*	...	...	196	27 03		
14	76	12·	44	20	66	64	...	194	16·16		
15	63	9·50	79	28	120	9*	...	236	24·84		
16	48	7·50	94	37	20*	...	...	151	20·13		
17	54	8·50	111	27	23*	..	...	161	18·94		
18	42	6·50	84	44	11*	...	...	139	21·38		
19	84	13·25	60	25	53	50	17*	205	15·47		
20	49	7·50	94	88	35*	...	...	212	28·26		

Although the variations in the observed growth are considerable, the number of annual rings in the first four inches of radius varying between 44 and 111, I think the figures are fairly reliable, and believe it will be found that a first class tree 6 feet in girth takes about 231 years (probably more than less) to grow.

It will be noted that in this sample area there were 84 deodars 2 feet girth and upwards per acre; the average height however was only 80 feet.

III.

Area and locality. Area two acres, situated on the right slope of the "Gordon Highlanders" gorge to the left of the Kotal and Ali Kheyl road.

Configuration, gradient and aspect. Unbroken slopes; average gradient 25°, with occasional bits of level ground. Elevation about 8,700 feet. Aspect north-west.

Rock and soil. Metamorphic rock with traces of iron. Soil deep, sandy, with much vegetable mould on surface.

Stock. In the sample area pure deodar; in the vicinity a few spruce and silver fir with some young blue pine are found.

Near the sample area is a clearing of about three chains square; this is nearly covered with saplings of about 4 feet

high; the growth consists of silver fir (9-10th), deodar (1-20th), spruce with a few blue pine (1-20th); beyond this clearing and in more shade are a few apparently *older* deodar and some sickly blue pine saplings. This clearing is surrounded on three sides by deodar, but nearly open on the ravine side (north-west); *it has two or three seed-bearing deodar in the middle*, and at the bottom of the ravine, about 50 yards away, are three solitary silver firs. It is quite possible this displacement of deodar by silver fir is due to the seed of that tree falling soon after the clearing was made, and before any deodar seed fell. On the other hand, I have in many places noted a decided tendency on the part of the silver fir to encroach on deodar growing on northerly aspects.

There was little or no undergrowth in this area.

Enumeration of Deodar.

Green Deodar.			Deodar Stumps.			Total Crop.			Remarks.
2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	
11	33	20	30	4	...	41	37	20	Partly old, partly new stumps—Few poles below 2 feet girth.

The height of the deodar here may be judged from the following measurements made :—

1. Girth 6 feet 9 inches; height 76 feet
2. " 8 " 6 " " 70 "
3. " 7 " 0 " " 71 "
4. " 6 " 6 " " 79 "
5. " 7 " 8 " " 84 "

Average height 77 feet.

The following number of stumps were examined to determine rate of growth; all the stumps were not in the sample area :—

Number.	Approximate girth of tree at 3 feet in inches.	Mean radius measured in inches.	Rings counted on radius.					Total number of rings.	Average number per inch per tree.	Average number per inch per locality.	Remarks.
			0 inch to 4 inches.	4 inches to 6 inches.	6 inches to 9 inches.	9 inches to 12 inches.	Above 12 inches.				
1	52	8	149	43	32	...	...	224	28·00	22·33	No. in 1 inch, ½ inch, &c.—*vide* radius measurement.
2	90	14·50	84	39	69	64	39	295	20·34		
3	65	10	67	57	72	23	...	219	21·90		
4	56	8·75	76	47	71	...	...	194	22·17		
5	78	12·75	53	27	54	54	16	204	16·00		
6	50	7·75	97	94	29	...	...	220	28·38		
7	51	8	56	71	75	...	...	202	25·25		

In this part of the forest with a north-west aspect, we find 49 trees of all classes per acre, average height 77 feet; age of a six-feet tree about 254 years.

IV.

Area and locality.

Area, two acres to right of Ali Kheyl and Kotal road, and beyond the Engineers' workshops.

Configuration, gradient and aspect.

The hill side is a good deal cut up by small water-courses, and has occasional bits of level ground with some abrupt rocky slopes; gradient 27°; elevation 8,660 feet; aspect southerly.

Rock and soil.

Limestone; soil poor, yellow clay with very little vegetable mould. The hill side has suffered from the wash of the snow water; some water springs are found near this sample area.

Stock.

Deodar with a few *holm oak* and *juniper*. *Undergrowth* very little, consisting of viburnum, wild flax and thistles. Reproduction entirely absent. A few trees about here have been injured by fires lit at their bases, and by barking.

Enumeration Survey.

Green Deodar.			Deodar Stumps.			Total Crop.			Remarks.
2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	2 feet to 4 feet 6 inches.	4 feet 6 inches to 6 feet.	Above 6 feet.	
2	6	21	21	11	16	23	17	37	Stumps partly old, partly new.

The following heights were noted:—

1.	Girth 11 feet 6 inches;	height 85 feet		Average height 79 feet.
2.	„ 9 „ 8 „	„ 89 „ ...		
3.	„ 9 „ 10 „	„ 79 „ ...		
4.	„ 8 „ 11 „	„ 70 „ ...		
5.	„ 11 „ 1 „	„ 73 „ ...		

Number.	Approximate girth of trees at 3 feet in inches.	Mean radius measured in inches.	Rings on mean radius.					Total number of rings.	Average number of rings per inch per tree.	Average number of rings per inch per locality.	Remarks.
			0 inch to 4 inches.	4 inches to 6 inches.	6 inches to 9 inches.	9 inches to 12 inches.	Above 12 inches.				
1	78	12·50	81	21	25	25	7	159	12·72	14·52	Nos. on 1 inch, 75, 25 &c.—*Vide* radius.
2	90	14·50	54	22	44	40	26	186	12·82		
3	84	13·50	69	36	15	14	...	134	9·92		
4	60	9·25	75	50	83	3	...	211	22·81		
5	71	11·25	65	33	55	43	...	196	17·42		

It will be seen from the preceding that the crop is only 39 trees per acre, and the average height but 79 feet. On the other hand, the growth is the most rapid yet found in these forests, a first-class tree taking only 165 years to grow. The rapidity of growth may be attributed to the trees growing on a sheltered southern slope in the vicinity of water.

V.

Area and locality.

About two and a half acres, lying about the hospital towards the Spingawai Pass.

Configuration, gradient and aspect.

The ground is steep and rocky near the main ridge, with huge masses of limestone protruding through the soil. The side spur, on which the sample area is, is rounded and even; the area measured runs into the ravine or dip between it and the next side spur. Gradient 23° to 25°. Elevation about 8,750 feet. Aspect southerly.

Rock and soil.

Limestone; soil clay; vegetable mould plentiful, save on ridge.

Stock.

Deodar and holm oak, with a little undergrowth of wild roses and viburnum. All the deodar have been felled and most of the oak. A large part of the hill side was burnt last summer when covered with leaves and branches, &c.; in the unburnt portion a good many deodar seedlings are visible; these are apparently two years' old; a few oak seedlings and coppice shoots are also found.

Deodar Stumps.			Oak Stumps.			Green Oak.			Total Crop, Deodar and Oak.		
2 ft. to 4 ft. 6 inches.	*4 ft. 6 inches to 6 ft.*	—	All Sizes.	—	—	All Sizes.	—	—	All Sizes.	—	—
36	46	63	127	...	...	49	...	...	321	...	...

This gives 58 deodar per acre, 128 deodar and oak per acre.

Measurements of girth of trees.

The following form gives the measurements of some of the deodar as found lying on ground after their tops and branches had been cut for fuel :—

Number.	Girth at butt end of tree about 4 feet from ground.		Girth at 14 feet from ground.		Girth at 24 feet from ground.		Girth at 34 feet from ground.		Girth at 44 feet from ground.		Girth at 54 feet from ground.		Girth at 64 feet from ground.		Girth at 74 feet from ground.		Girth at 84 feet from ground.		Girth at 94 feet from ground.	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
1	9	0	8	6	7	6	6	0	4	6	...	...	...	...	...	...	...	...	...	...
2	6	0	5	6	5	2	4	10	3	7	...	...	...	...	...	...	...	...	...	...
3	8	9	7	4	6	9	5	3	3	9	...	...	...	...	...	...	...	...	...	...
4	6	3	5	9	6	0	5	0	4	3	...	...	...	...	...	...	...	...	...	...
5	8	9	8	0	7	6	7	0	6	6	...	...	...	...	...	...	...	...	...	...
6	8	7	7	3	6	4	6	0	5	0	4	3	...	...	...	...	...	...	...	...
7	12	0	9	7	9	6	8	6	8	0	...	...	...	...	...	...	...	...	...	...
8	9	0	7	0	6	3	5	9	5	3	4	2	3	3	2	9	...	...	...	...
9	4	0	4	0	4	0	4	0	3	8	3	0	2	8	1	8	...	...	...	...
10	7	9	7	3	6	6	5	3	5	3	4	0	...	...	...	...	...	...	...	...
11	6	3	5	2	4	3	3	7	3	0	2	0	...	...	...	...	...	...	...	...
12	7	0	6	10	6	2	5	7	4	6	4	3	...	...	...	...	...	...	...	...
13	9	0	7	4	6	6	5	11	5	0	4	3	3	0	...	...	...	...	...	...
14	11	0	9	9	9	0	8	0	7	0	6	6	5	6	4	6	3	9	...	...
15	5	0	4	9	5	0	4	9	4	6	4	0	3	0	...	...	...	...	...	...
16	6	8	6	0	5	6	5	0	3	6	3	0	...	...	...	...	...	...	...	...
17	11	0	12	0	10	6	9	9	8	9	8	0	7	2	6	...	5	3	...	...
18	7	8	8	0	8	0	7	8	7	6	7	0	6	9	...	...	...	...	...	...
19	7	9	7	3	7	3	5	0	4	8	3	9	...	...	...	...	...	...	...	...
20	10	0	9	3	8	9	8	6	8	3	7	3	6	6	6	...	...	...	...	...
21	8	0	8	0	7	3	6	11	6	6	6	0	5	9	4	6	...	...	...	...
22	8	2	8	0	7	6	6	9	5	10	5	3	4	11	...	...	...	...	...	...
23	8	8	8	0	8	4	6	9	6	1	5	6	...	...	...	...	...	...	...	...
24	10	0	8	3	7	0	6	3	5	9	5	0	3	9	2	9	...	...	...	...
25	7	0	7	0	6	6	6	6	6	3	5	0	4	4	3	6	...	...	...	...
26	6	8	5	6	4	9	4	0	3	3	2	3	...	...	...	...	...	...	...	...
27	8	9	8	9	7	9	7	3	6	0	5	0	4	0	2	9	...	...	...	...
28	7	0	6	3	5	9	4	9	4	6	...	...	...	...	...	...	...	...	...	...
29	9	0	8	6	8	4	6	9	5	1	...	...	...	...	...	...	...	...	...	...
30	6	8	5	9	5	9	5	0	4	3	4	0	...	...	...	...	...	...	...	...
31	6	3	5	8	5	0	4	8	4	8	4	0	...	...	...	...	...	...	...	...
32	8	9	6	0	5	0	4	9	3	6	2	6	...	...	...	...	...	...	...	...
33	8	0	7	3	6	3	5	6	4	3	2	3	...	...	...	...	...	...	...	...

This sample area was selected as one largely stocked with oaks, and as affording a good opportunity of measuring a number of trees. It was found, however, that the trees had been so much damaged in the collection of fuel that the measurements of only one-fourth were worth recording.

Rate of growth.

Number.	Approximate girth at about 3 feet from ground in inches.	Mean radius counted in inches.	Rings counted on Radius. 0 in. to 4 in.	4 in. to 6 in.	6 in. to 9 in.	9 in. to 12 in.	Above 12 in.	Total number of rings.	Average number of rings per inch per tree.	Average number of rings per inch per locality.	Remarks.
1	84	13·50	64	17	77	118	60	336	24·88	21·61	No. rings ·75, 1·00, 2·00, 2·25, &c.—*vide* radius.
2	73	11·50	118	63	86	43	...	310	26·95		
3	81	13·	95	67	63	52	17	294	22·61		
4	78	12·50	117	54	79	43	8	301	24·08		
5	81	13·	118	42	66	34	9	269	20·69		
6	92	15·	74	31	41	67	121	334	22·26		
7	71	11·	67	21	45	35	...	168	15·27		
8	121	19·75	56	41	32	34	186	349	17·67		

It will be noted that while the aspect of this plot is southerly, the growth is much slower than in the godown plot (No. 4). This may be accounted for by the dry nature of the spur, rock being near the surface, &c., but also tends to show that growth near the godown is abnormally quick. The age of a first class tree (6 feet girth) appears to be 246 years in the hospital plot, or slower in growth than an average tree in these forests.

IV. Notes, Queries and Extracts.

Pruning Forest Trees.—Great difference of opinion prevails as to the necessity for pruning forest trees and the season at which such operations should be carried out. But undoubtedly the weight of authority is favourable to early summer pruning. The month of June is strongly recommended, because at that time the wounds heal up much quicker than during July or August, when the motion of the sap becomes slower. *And it should be a standing rule with the pruner that* no wound remain exposed to the action of the atmosphere for a longer period than one year. If the aim of the owner of woodlands was confined to the production of the greatest amount of wood upon a given area in the shortest possible time, it is questionable whether pruning of any kind should be executed; for every branch cut away from a tree lessens the quantity of foliage presented to the action of the sun and the atmosphere, and therefore decreases the absorption of carbonic acid gas and the formation of wood, of which carbon is the main constituent. But where the object in view is the growth of the maximum of straight, lengthy, clean, and sound timber, thinning and pruning must commence soon after planting, and continue until the trees attain considerable proportions. By thick planting, early thinning, and careful stopping of rambling shoots or rival leaders, pruning will seldom be necessary except in the removal of injured branches. But as the growth of a tree is slow, and he who plants seldom lives to train up his trees to maturity, pruning in an advanced stage of their growth is often necessary in order to lessen the evils resulting from *early neglect.*

Trees differ so much in habit and in their rapidity of growth, and are so largely dependent upon the soil and situation in which they are placed, that it is impossible to lay down any precise rules for their management in this respect. Those intended to form large and good timber should never at any stage of their growth be suffered to become too much crowded, nor overtopped or whipped by their nurses; and as they rise they should be allowed sufficient space to enable them to develop well-proportioned heads, equal in length to from one-third to one-half the height of the entire tree. It should also be borne in mind that by preserving a complete canopy of foliage overhead the moisture is retained in the soil, the stems rise rapidly and the formation of side branches is retained.

The advantages of early pruning are nowhere more observable than in young plantations of Oak and Spanish Chestnut. Two years after planting it is no uncommon occurrence to find a considerable number of the young trees hide-bound and becoming distorted in their growth. Such, if left to themselves, seldom or never attain to the size of timber trees. But if cut over with a clean section within two inches of the ground, they will push forward vigorously during the following spring and summer. By rubbing off all but two of the strongest shoots in June or July, and allowing these to grew on together until the following March, and then cutting out the weaker of the two, and afterwards keeping the other single upon the stub, a vigorous growth may be insured, which will, in a few years, far exceed that of the uncut trees. A most remarkable instance of this is mentioned by Forsyth, who, the second year after planting a bed of Oaks, headed down one-half and left the other to grow naturally. In giving an account of their progress a few years afterwards, he states that one of the plants thus cut over was 18 feet high and 15 inches in circumference at 6 inches from the ground, while the largest of the uncut ones was only 5½ feet high and about 4 inches in circumference.

But, while recommending the early and careful pruning of forest trees, I would not be considered as an advocate of the excessive lopping and pruning introduced by Pontey, and so ruthlessly carried on by his successors, who looked upon and spoke of the branches of trees as being merely "robbers of the stems." To produce lengthy timber every branch which threatens to rival the leader should be shortened. By adopting this method instead of cutting away the branch entirely the trunk is strengthened by the sap being detained in its descent. Timely attention will obviate the necessity for heavy prunings at any stage of a tree's growth. The pruner should, however, be conversant with vegetable physiology, otherwise that twilight of uncertainty, in which all his operations are performed, may lead him to commit grave errors. In close plantations the destruction of the lower branches is eventually caused by the exclusion of light, but the result is generally unsoundness of stem. This is found to be the case so extensively in Canada and other large timber-producing countries, that a very small proportion of the trees grown under such circumstances are fit for exportation.

The whole art of pruning and training timber centres is the adoption of a proper mean between the two extremes of cutting away the branches of a tree so as to give it the appearance of a mere May-pole in the one case, and that of a dense spreading bush in the other. A severe mutilation of the head of any tree must for a long time paralyse the action of its roots, and on this account the heavy pruning of neglected trees, if undertaken at all, should be extended over two or three seasons.

Deciduous trees will require the most careful training in order to produce sound timber. As considerable difficulty is experienced in pruning trees of a resinous kind without injury to their growth, it becomes the more necessary to plant and rear them in close order. The lower branches under these circumstances are soon killed back, and may be removed so that the longitudinal structure of the bole is but little injured, as, by the early destruction of the laterals, the superincumbent layers of wood are entirely free from knots. Thus it happens that Fir timber grown in close plantations, where the early removal of the dead, bolt-like insertions left by the dead branches is attended to, becomes the most valuable, while single trees, from their coarseness of grain and abundance of large knots, are almost worthless to the builder. It is also found that Ash grown in close plantations becomes much tougher and clearer in the grain.

In exposed situations both the pruning and the thinning of trees should be much lighter around those margins of plantations which face the prevailing high winds of the district. By too close packing it often happens that only the face of the very outermost trees are clothed with foliage, so that any injury to one of these admits the destructive winds. This may be guarded against by a judicious early thinning of such margins, so as to secure a belt of low-branched trees.—(A. J. BURROWS, *in 'The Garden.'*)

SOME short time ago samples of the gums or rather guttapercha given by three of the Indian Figs (*F. indica, F. religiosa* and *F. glomerata*) were sent to England for report on their value. The following is an extract from a letter from Mr. Matthew Gray, General Manufacturer, India Rubber, Guttapercha, and Telegraph Works Company:—

"We have received your letter of the 31st ultimo, and have examined the three samples of dried *Ficus* milk which you sent to us. We have no doubt they are all of some commercial value *if properly collected and carefully dried.* The samples were too small for us to form any correct opinion of their commercial value, and we would feel much obliged to you if you could get sent to us about 100lbs. of each of the three sorts, that will enable us to test in some practical manner their value.

It is of the greatest importance in collecting the milk and drying it, that it be done with care and in a proper manner, so that it be kept clean and no decomposition take place in the drying. To do this, it is necessary that the drying be done under a roof supported by poles, to screen the milk from the direct rays of the sun. Trays for drying the milk should be made of common deal timber, say three feet long and eighteen inches wide, with side and ends about three inches high; these trays are put upon supports below the roof, and into them is

poured the milk about one-eighth of an inch deep; this is allowed to remain until it is dry or nearly dry, when another layer of milk is put on top about one-eighth of an inch in depth, which is allowed to dry. This process is repeated until a cake of two or three inches in thickness is made up, when it can be turned out of the tray in a dry cake of firm dry gum, three feet long, eighteen inches broad, and two or three inches thick. This care in the drying of the gum may appear unnecessary to those who collect it, but years of experience has proved to us the necessity of doing it as we describe; we have found that if it is dried with the direct rays of the sun bearing upon it, decomposition takes place, or if dried in too thick a mass the outside of the mass gets dry and firm, while the centre contains moisture and induces decomposition, thereby injuring the quality of the gum very much."

THE AMERICAN YELLOW CEDAR OR CYPRESS.—An American paper states that this noble tree sometimes attains a height of 150 feet, and a diameter of from three to five feet. The branches are pinnate, drooping, feathery, dividing into beautiful light-green sprays, like those of the California *Libocedrus*, but with finer foliage and more delicate plumes. The wood of this tree is undoubtedly the best the country affords, and one of the most valuable to be found on the whole Pacific coast. It is pale yellow, close-grained, tough, durable, and takes a good polish; and to these qualities is added a pleasant fragrance, like that of sandalwood.

The only California wood that resembles this is the torrega, which has the same delicate yellow colour and close texture, but the pleasant scent is wanting, while the trees are small and scattered in and out of the canyons. Some three or four ships have been built of yellow cedar, and small quantities, a few thousand feet at a time, have been sent to Portland and San Francisco from Sitka, Fort Wrangel, Checan, and Port Simpson, probably less than a milion feet in all. Some little goes to China, and is made into fancy boxes, it is said, to be returned to us for camphor-wood. It deserves to be far better known, not only to shipbuilders, but to carpenters and furniture-makers. The Indians make their paddles of it, and weave matting and coarse cloth from the inner bark of the tree, which is quite durable, and of a fine brown colour. It is also the favourite firewood of the coast region, burning very freely, though it does not last long. A yellow cedar fire, to any one witnessing it for the first time, is quite a notable phenomenon. The flames quiver and rush up in a multitude of ragged-edged lances, while the burning surfaces snap and crackle and explode, and throw out a shower of glowing coals with such a noise that conversation in an ordinary pitch of voice is at times

impossible. Every open hearth in which this wood is burned, has to be closely screened with a framework of wire netting, else the floor would be strewn with cinders. The durability of this timber is forcibly illustrated by the fallen trunks lying in the damp woods. Many of the largest of them last for centuries, retaining even the delicate colour and fragrance unimpaired. Soon after they fall they are overgrown with moss, in which seeds lodge and germinate, and grow up into vigorous saplings, standing all in a row on the backs of their ancestors. As they grow larger they stand astride, sending their roots down and out on both sides, like the straddling legs of a spider. And, after they have reached an age of several hundred years, the downtrodden trunk, when cut into, will almost always be found as fresh in the heart as it was when it fell. Decay goes slowly on from the outside, never commencing in the heartwood, as far as I have noticed, though a good many of the living trees are injured by a fungus which produces a dry rot similar to that found in Thuja and Libocedrus. The species is found as far south as Vancouver Island, and is pretty generally distributed along the coast and through the islands, as far north as Sitka,—how much farther in either direction I am unable to say. But though its range is thus extensive, it does not seem to be very abundant in any one place, or to occupy any considerable area to the exclusion of other species.—*Timber Trades Journal.*

FORESTS OF THE CAUCASUS.—Reporting on the trade and commerce of the Caucasian Provinces, Acting-Consul Lyall, after referring to the immense extent of forest-covered area existing in the Caucasus, points to the fact of their being of little or no commercial value. He says, wherever means of transport to a market exists, either by rafting down a river or the vicinity of the seaboard, the forests have either been already denuded of good trees, or exorbitant prices are demanded for the right to fell. The mountains round Tiflis have, for many years, been completely cleared even of brushwood, and firewood is in consequence very dear. The practice of denuding the mountains, which goes on throughout the Valley of the Kour, has resulted in either completely drying up, or diminishing seriously, the volume of water in the rivers. It may be expected, unless measures are taken for re-afforesting the mountains, or some scientific methods of irrigation introduced, that famines will before long take place. The Government of the Caucasus have long had a complete reorganization of the existing Forest Department under consideration, but this reform, like many others just as urgently required, has hitherto been postpond *sine die.*—*Ibid.*

A Log Railroad.—The log tramway or railroad in use by the Richardson Brothers at their mill, south of Truckee, is a very ingenious piece of machinery. Logs ten inches or a foot in diameter are hewn round and smooth, and their ends are coupled together by iron bands. These logs, laid side by side upon graded ground for a distance of perhaps three miles from the track. Of course the road looks quite like an ordinary railroad track, except that logs are used instead of rails, and the ties are at much greater intervals. The wheels of the engine and cars are concave on their outer surface, and fit the curve of the logs. The power is applied to a wheel in the middle of the forward axle of the engine. The most remarkable loads of logs are hauled upon the cars, and the affair is a decided success. It is very cheap, its construction is simple, it is not easily damaged, and its operation is all that could be desired. By means of this log railroad the Richardson Brothers are enabled to get their logs to the mill from the forest, three miles distant, at a cost far less than is ordinarily done.—*Truckee Republican.—I bid.*

Forest Fires.—Thousands of acres of wild and cultivated lands have been devastated recently by extensive forest fires in New Jersey, Pennsylvania, and Virginia. The country about Tuckerton and Tom's River and Forked River, New Jersey, has been swept over by the flames, and cranberry bogs, strawberry farms, timber, dwellings, barns, and live stock destroyed. The well-known shooting grounds in that region have been utterly destroyed. The singed bodies of thousands of quail and other game birds, and rabbits, have been found on the outskirts of the burned districts. Immense quantities of game have also been destroyed in Monroe and Pike counties, in Pennsylvania. Warm, dry, and windy weather has prevailed in Virginia for several weeks past, and these forest fires there are reported unprecedented in extent and damage. The fires in the dismal swamp have been raging for more than a week. They envelop the whole of Lake Drummond. The cultivated sections of the adjoining country are overrun with bears, panthers, deer, and smaller game. A Reuter's telegram, dated New York May 13th, says :—Fires have broken out in the forests in the south of New Jersey, and in the oil regions of Pennsylvania. The conflagration is spreading, and causes immense destruction of oil and agricultural property. Several small villages have been destroyed by the flames.—*I bid.*

Preserving Wood.—The improved French method of preserving wood by the application of lime is found to work well. The plan is to pile the planks in a tank, and to put over all a layer of quicklime, which is gradually slacked with water.

Timber for mines requires about a week to be thoroughly impregnated, and other timber more or less time according to its thickness. The material acquires remarkable consistence and hardness, it is stated, on being subjected to this simple process, and the assertion is made that it will never rot. Beechwood, prepared in this way for hammers and other tools for ironwork, is found to acquire the hardness of oak without parting with any of its well-known elasticity or toughness, and it also lasts longer.—*Ibid.*

ARIZONA SHELLAC.—At a recent meeting of the California Academy of Sciences, Professor Stillman read a paper on the gum and colouring matter found on the *Acacia Greggii* and *Larrea Mexicana,* or creosote plant. The gum which exudes from these plants is very abundant, and is the product known to commerce as shellac. The same plants produce lac dye. Professor Stillman suggested that California might compete with British India in supplying this valuable product. Mr. B. B. Redding said that these lac-yielding plants were as plentiful as sagebrush, from Southern Utah to New Mexico, and from the Colorado Desert to Western Texas.

The lac is most abundant around stations on the Mojave and Colorado deserts, and exudes as the result of an insect's sting. Calcutta exports a million pounds sterling in value, annually, of shellac, selling at 25 to 35 cents a pound; and almost as much more of lac-dye, selling at 30 to 40 cents a pound. In 1876, the United States imported 700,000 pounds of shellac alone. To collect this is simple work for boys, and will prove an important industry. It will require little or no capital. The twings are boiled in hot water, and the gum rises to the top, is skimmed off, strained, and dried on smooth stones, and handpressed into flakes, ready to make sealing-wax or varnish. The residue, when allowed to settle, makes lac-dye. The plants live on a rainfall of three inches a year.

In Vol. VI (Botany) of the reports of the U. S. Geographical Surveys, west of the 100th meridian, we find the following information relative to these two plants which would seem to be worthy the attention of commercial men and manufacturers, page 108—*Acacia Greggii,* Gray.—A small tree, 10 to 20 feet high, pubescent or glabrous, unarmed or with scattered, stout recurved prickles; pinnæ 2 or 3 pairs, on a slender petiole; leaflets 4 or 5 pairs, oblong or oblong-ovate, 2 or 3 lines long, rounded or truncate above, narrower at base, rather thick, and with 2 or 3 straight nerves; flowers in cylindrical spikes an inch or two long, the peduncles equalling or exceeding the leaves; pods thin, coriaceous, flat, 3 or 4 inches long by 5 to 7 lines broad, shortly stipulate, acute, curved, glabrous, and reticulated, more or less constricted between the seeds;

seeds half an inch long. From Western Texas to Southern California; collected in Western Arizona, 1872.

Page 41—*Larrea Mexicana*, Moricand, *Creosote bush*.—Common from Western Texas to Kern County, California, and southward to Mexico. Dr. Loew's examination proves that the reddish brown exudation on the branches, caused by an insect, will yield a red coloring matter showing all the reactions of cochineal. "The alcoholic extract of the leaves, on evaporation, yields a greenish brown residue of a specific and somewhat disagreeable odour, more strongly perceptible on boiling the extract with water. This residue is only, to a small extent, soluble in water, and the solution has an acid reaction. It yields a light yellow precipitate with acetate of lead. The part of the alcoholic extract, that is insoluble in water, is easily soluble in alkalies. It also dissolves in nitric acid at a moderate heat, whereby exudation takes place. On addition of water a yellow brittle mass is precipitated." The Mexicans are said to use an infusion of the leaves for bathing in with good effect in rheumatic affections. (Also Vol. III, Wheeler's Reports.)

Page 80—*Larrea Mexicana*, Moric. (*L. glutinosa*, Engelmann),—Valley of the Gila, Arizona. This shrub is especially common on the hills bordering the Gila, also on the sandy wastes adjacent to Tucson and Camp Lowell, in Arizona, even imparting its strong odour to the air.

In the third volume of these reports this plant is also called stinkweed.—*Scientific American.*

In a recent number of the *Asian*, in a kind notice of our Journal, the reviewer, referring to our note on the subject of toughened glass for sleepers, refers us to *The Month*, in a late number of *Chambers' Journal*, where it is stated that "where glass sleepers have been laid by way of experiment they stand wear and tear as well as iron, perhaps better, for they do not corrode." On the same subject we now extract from the *Timber Trades Journal* as follows :—

"Toughened Glass Sleepers.—In regard to this subject the New York *Manufacturer and Builder* says :—We feel inclined to express our lack of confidence in the practical application of this material for railroad sleepers. The advantages of wooden sleepers are, that railroad spikes are easily driven into them; but how about making reliable fastenings of the rails to glass? And how about tightening when a rail becomes loose? Then wood possesses an elasticity which is not only very desirable as a seat for the rails, but necessary. On the first experimental elevated railroad in Greenwich-street, this city, the rails were fastened directly upon the large T pieces which crowned the columns supporting the road; a great improvement was effected by putting wooden sleepers across on top of these rails, and then other rails on top of these sleepers; and this is essentially the principle upon which now all the New York elevated railroads are constructed. Another example occurs to our mind. Some forty years

ago the Camden and Amboy Railroad, between New York and Philadelphia, was built on stone sleepers. It was supposed that as stone was so much superior to wood in solidity and durability, it would be a great advantage, not only in strength, but also in cost of repair. These stone sleepers and piers were all removed thirty years ago and wooden sleepers substituted, and we do not see why glass would have any advantage over stone. The stone referred to was granite, some varieties of which are about as strong as the toughened glass referred to."

WE have received the Report for 1878-79 of the Ootacamand Botanical Garden, which presents but little of forest interest. It is stated that the Araucaria (*A. Bidwilli*) thrives admirably on the Nilgiris, one specimen, only twelve years old, having reached a height of over 28 feet. Mahogany, too, seems to be doing well, though we should certainly have thought that the attitude would be too great for it.

The success of the Cocoa plant in the Nilgiris, as well as of Liberian coffee, seems to be the chief point of interest in this report. The former seems to have been most successful, while the growth of the latter seems to be very fast and healthy.

A NEW variety of the Cedar has been discovered in Cyprus. It was, we believe, first brought to notice by Sir Samuel Baker. It is very uncommon, being found in only one locality in the mountains. In character it is said to resemble more nearly the Atlas Cedar than the Cedar of Lebanon or the Deodar.

IN an article in the *Asian*, to which we have already referred, it seems to be supposed that the translation of an Italian paper on the Carob tree by Mr. Duthie, which appeared in our last number, was taken from the journal of the Agri-Horticultural Society. This, too, the Society seem to think, for we have received letters from their Secretary requesting us to "acknowledge that the paper was taken from their journal." However, we are afraid the Society will not get any such acknowledgment this time, the fact being that the paper was placed in our hands in manuscript last January, only just too late for the January number and possibly as soon as it was received by the Society. At the time we sent the paper to press, we were unaware of the Society's also having published it, or we should probably have left them the whole of the honor and glory of producing our friend Mr. Duthie's interesting translation.

ON the 9th May last, at three o'clock in the afternoon, a fire broke out in the Forest of Fontainebleau in the part known as the *Gorges d'Aspremont*. The fire which, it seems probable, was due to the carelessness of a smoker, spread

rapidly in the dry grass and among some young maritime pieces which had been killed by the winter frosts. The damage done was estimated at 3,000 francs, and the area burnt over was about 10 hectares. It was extinguished in the evening with the assistance of passers-by and a detachment of the 11th Hussars.—*Revue des Eaux et Forêts.*

THE FOREST ACT IN BOMBAY.—The *Bombay Gazette* regrets to learn that since Sir Richard Temple's departure there has been an attempt to reverse, at least to modify to a considerable extent, that forest policy which he so successfully, and in the face of great official opposition, introduced into the Presidency. Believing, as this paper does, that upon the proper protection of forests, and on the *re-clothing of the denuded hills of the* Deccan with vegetation, depends in no small degree the future prosperity of this country, the reversal of the lately inaugurated forest system would in its opinion be a national calamity. After quoting in support of the policy of the Act the example of the efforts now being made by the Americans to reaffores their country the article continues: "it is asserted that the application of the Forest Act entails very great hardship on the people. We believe the reports of these hardships to be very greatly exaggerated. The Act provides that no ground shall be taken over unless all claims have first been settled. Is it seriously maintained that this provision is inoperative? If claims on the waste taken over be once settled, a villager chooses to enter a Government plantation and to cut down young trees, he deserves no sympathy if he is punished. Moreover, the intention of the Act is not to stop the consumption of timber, but simply to regulate it and to provide for the replacement of whatever is cut down. If the villagers were allowed to have their own way, there would soon be not a tree in the country. So for their own good, and above all for the *good—even the safety—of the millions who have* as much right to these forests as the few villagers who live near them, the provisions of the Forest Act must be carried out. It is also said that conservation of waste lands means a diminution in the supply of forage. That is not the case; on the contrary, land that is conserved yields ten times more forage than bare tracts exposed to the scorching sun, and from which the earth is year by year being wasted away. All that the Forest Act requires is, that the people shall desist from sending their goats and sheep into conserved tracts until the trees are strong enough to be left to themselves. We sincerely hope that the Governor and his more immediate advisers will not be led away by clamour, but will steadily carry out the policy of reafforesting the wastes which it was the proudest achievement of his predecessor to lay down."—*Pioneer.*

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Alfred Pengelly.

MOST of our readers will have heard ere this that Alfred Pengelly has been killed by a black bear throwing him down a precipice in Chamba. By his death Government has lost an excellent servant, and all those who had the privilege of being personally acquainted with him, deplore the untimely death of one whose character was without a blemish.

Alfred Pengelly, born in 1843, was the son of William Pengelly, Esq., F. R. S., F. G. S., etc., who resides at Torquay, and who is well known as a scientific geologist. In the year 1852, when 9 years old, he left his home for school, spending five years at Sidcoe in Somersetshire, two years at Bootham in the city of York, and two years at the Flounder's Institute, Ashworth, Yorkshire. From 1861 to 1863 he spent as junior teacher at Bootham, York.

In 1861 he matriculated at the London University, but instead of proceeding to his degree at that University, he entered, in October 1863, at Christ's College, Cambridge, where he gained a mathematical scholarship, and was a senior optime in the Mathematical Tripos in 1866. He became Master of Arts in 1869 if we are not mistaken.

In spring 1867 Her Majesty's Secretary of State for India decided on offering a certain number of appointments in the Indian Forest Department to young Englishmen, the appointments to be filled by means of a competitive examination, and the successful candidates to be sent either to Germany or France for the purpose of studying forestry, preparatory to their joining their appointments in India. Alfred Pengelly headed the list of the first year, and he arrived after having spent two and a half years at the French Forest School at Nancy, and in the forest of Haguenau, arriving in India towards the end of 1869. He was posted to Sind, where he, in conjunction with Mr. F. R. Dasai, assisted Dr. W. Schlich, then on special duty in Sind, in the examination of the forests of that province, and in the collection of data for a working plan.

Owing to repeated attacks of low Sind fever, he was, in 1871, transferred to the North-Western Provinces, and stationed at Chakrata.

For some time he was in charge of the forests near the military station of Ranikhet, where he organized the supply of wood to the Cantonment, and demarcated a portion of the reserves destined to supply the station with forest produce.

In 1875 he was engaged in making an examination of the Kumaun Iron Works Forests at the foot of the hills below Naini Tál, in the Kotah Division.

In October 1876, his services were placed at the disposal of the Government of the Punjab; he did however not join in the Punjab until in February 1877, when he was appointed to the charge of the Ravi Forest Division, and instructed to push on the demarcation of the Chamba reserves.

In February 1878 he proceeded on one year's furlough. On his return in February 1879, he was posted to the charge of the Fuel Reserve Northern Division, but already in May of the same year he proceeded on six month's leave on urgent private affairs, from which he returned in December 1879. He was then attached to the direction and employed in the examination of the Lahore rakhs.

On the 1st January 1880, he took temporarily charge of the Conservator of Forests' Office, until the arrival of the new Conservator on the 26th January 1880, when he returned to the examination of the Lahore rakhs.

Early in April 1880 he proceeded to Chamba, specially charged with the demarcation of reserves in that State. In this work he made capital progress.

It was early in the morning of the 29th July 1880, when his servants woke him and told him that a black bear was close by eating the villagers' fruit. He dressed quickly, went out, fired at the bear and missed it. The latter went off, and Alfred Pengelly followed it up with a favourite and most excellent little fox terrier, "Vixen." He traced the bear to a cave, situated above a precipice, and approachable only by a narrow path. Vixen could not be stopped, and went in at the bear. Alfred Pengelly, hearing his dog being punished by the beast, went to his assistance along the narrow path. Suddenly the bear rushed out, and before he could fire, Alfred Pengelly was seen falling over the precipice. Whether the bear actually pushed him down, or whether Pengelly, in trying to avoid the bear, stepped over the edge of the precipice, has not been ascertained. He fell clear down for upwards of 300 feet, and death was instantaneous.

Having stood at the head of the first year's trained English Forest Officers, Alfred Pengelly may be called the leader of that section of the forest service, which position he filled most worthily, not only on account of his attainments in general and

forest knowledge, but also, and perhaps more so, because of his thoroughly upright and simple-minded character. He was a true friend; and although his life cannot boast of any specially brilliant episodes, yet he was a man one does not meet with every day.

Alfred Pengelly married about two years ago. He lost his only child nearly a month before his death, and he leaves a young widow mourning his loss.

Sw.

Proposed fire protection in the forests along the south-western declivity of the Sewalik Range for the purpose of diminishing the floods which now reach the Ganges Canal.

NUMEROUS as the opportunities are for demonstrating in India the fact that the damage done by floods may be diminished by creating or improving forests on hitherto more or less barren hill tracts, it is rare that actual measures can be taken. The damage done by the floods, or the advantages to be derived from their cessation, must be very obvious and striking to cause the necessary outlay to be granted. The following are instances where special circumstances have caused, or are expected to cause, immediate measures.

Mr. Baden-Powell brought to notice the very serious damage done by torrents locally called "Chôs" in the Hoshiarpur district. These Chôs spread so much sand from the barren hills over the adjoining plains that every year the cultivated lands are more seriously encroached upon.

In Ajmere and Merwara the water is very scarce, and everything depends upon the proper utilization of the rainfall. For this purpose the hill sides were brought under protection, and the new formed forest growth is expected to prevent silting up of valuable tanks, to diminish the excessive evaporation of water from the ground, to produce a more permanent subterraneous flow of water to tanks and wells, and to attract more rain.

In the Pabbi hills, near Jhelam, a system of protection was commenced by Mr. Reuther, with the same object of economizing the rainfall, and regulating its discharge from the surface.

In the case of the south-western declivity of the Sewalik Range, the floods, which rush down in numerous mountain torrents (called Raus) during the rainy season, cross the lines of the two great canals, the Ganges and the Eastern Jumna. The great importance of these canals, and the enormous cost of the engineering works required for their protection, supply the special motive for improving the forests of the drainage area of the torrents.

It cannot be said that the south-western declivity of the Sewaliks is devoid of forest. There are forests, but they are less than half stocked with trees, and there is a very scanty undergrowth and little soil, by reason of the fires which pass through them every dry season, and cause continual damage. By merely keeping out the fires, the growth of the forest and the accumulation of a protecting layer of vegetable mould would be much favored, so that in the course of some years a great improvement would take place. The discharge of the rain water from the surface would be spread over a greater length of time, and the sudden floods of only a few hours duration, which are now so dangerous, would be reduced. Further, the amount of detritus and sand now carried down upon the lines of the great canals would very much diminish.

The provision made at the Ganges canal for passing off the floods from the Sewaliks is of four different kinds:—

(*a*). The minor drainage channels are simply permitted to enter the canal.

(*b*). Two rivers, the Ranipur and the Patri, are conveyed over the canal by super-passages.

(*c*). The Ratman river passes through the canal by means of dams and sluices on a level with the canal.

(*d*). The Solani passes underneath the Ganges canal, which is carried on the great Solani aqueduct.

The total cost of these works was nearly half a crore of rupees. Compared with the mere interest on such a sum, irrespective of the cost of maintaining the works, the cost of protecting the whole forest area from fire is quite trifling.

The matter having been laid before the Government of the North-Western Provinces, it remains to be seen whether the Canal Department will consider it their interest to contribute towards the expenses of protecting the forests from fire. One portion of the area deserves first attention, that of the Ratman river basin. It includes ten miles length of the Sewalik range. The arrangements for crossing the Ganges canal at the Ratman are of a less permanent character. They involve the keeping up of a permanent establishment for the working of the sluices, by which the floods and the canal water are alternately passed off. They cause repeated stoppages of the canal, and the floods must carry large quantities of detritus, not only through the canal, but also into the canal. Arrangements will, therefore, be made for protecting the mountainous portion of the Ratman catchment area. The cost of protection will only be about Rs. 2,000 a year, whilst the engineering works at the Ratman represent a capital of five lakhs of rupees, with Rs. 20,000 mere interest every year.

The questions now, are: *Firstly*, to what extent the floods will be finally reduced? *Secondly*, to what extent will the transport of debris and sand across the Ganges canal be reduced?

Thirdly, what period of successful fire protection will elapse before marked effects will be observed? And, *Fourthly*, when will the maximum effect have been approached?

H. WARTH.

DEHRA DUN, *the 27th July* 1880.

Durability of Indian Railway Sleepers, and the rules for marking them.

THE following is an abstract of the replies received from the several railway authorities to an enquiry made by Government as to the durability and average age of railway sleepers of the different kinds of wood in use:—

East Indian Railway.—Cannot give any definite information as to the ages of the different kinds of woods used for sleepers on this railway, as the system of branding has been defective.

Speaks of sál as being the most durable of Indian woods, and states that the average life of sleepers of sál on the railway has been 14 years.

Eastern Bengal Railway.—Teak, sál, jarúl, and iron-wood sleepers in use: average ages:—

Teak	14 years.
Sál	13 „
Hard-wood, Jarúl, &c.	$8\frac{1}{2}$ „
Iron-wood	12 „

Consulting Engineer explains that these figures show the time the sleepers have already been on the line.

Creosoted pine sleepers obtained from England are also in use, and some, which have been $18\frac{1}{2}$ years in the road, are yet serviceable.

Northern Bengal Railway.—Sál in use, but for so short a time that it would be difficult to pronounce any definite opinion as to its durability.

63,000 sál sleepers laid, time about four years, and renewals have been at the rate of 14 per cent. Government of Bengal is of opinion that this percentage is due to the use, in the first instance, of sapwood; it having been found that where heart wood was used, no signs of splitting or decay have appeared, and that on the whole sál sleepers make a very satisfactory road.

Tirhoot Railway.—Deodar and sál sleepers in use. The former has been laid over 5 years, and most of the sleepers on the line show no signs of deterioration. There have been failures, but these, it is stated, are due to the necessity for frequent shifting, and the consequent use of additional spike

holes, when relaying, resulting in splitting; these sleepers were originally laid on the famine line.

Sál has been laid over two years, and so far has stood well.

Creosoted pine also in use, but does not last as well as deodar or sál.

*Calcutta and South-Eastern Railway.**—Manager finds sál and teak more durable than creosoted pine, the average life of which is given at three or four years. He says nothing, however, as to the age of sál and teak.

Punjab Northern and Indus Valley Railways.—No records kept up hitherto.

Deodar in use on both railways, and creosoted pine also on the latter.

Nalhati Railway.—Red gum and creosoted pine in use; former more durable.

Sind, Punjab and Delhi Railway.—Deodar and creosoted pine in use.

Deodar, average life	...	...	12·34 years
Pine ,,	...	...	16·35 ,,

No jungle woods in use on the *Rajputana Railway.*

The Government of India have prescribed the following rules for the marking and registration of sleepers:—

Rules prepared by the Consulting Engineer to the Government of India for State Railways, for the Marking and Registration of Timber Sleepers.

The present system of branding sleepers will be discontinued, and a system of marks on zinc nails will be substituted for it.

2. The marking and registration will be confined to a few selected miles.

3. The miles on which registration is to be adopted should be selected so as to afford different conditions of curve, gradient, ballast, &c., which may affect the life of a sleeper.

4. Every kind of timber in extensive use for sleepers should be included in the selected miles.

5. In case any railway is less than 50 miles in length, no *detailed* sleeper registration need be kept.

6. On lines exceeding 50 miles in length, the number of miles selected for registration shall be one for every 50 miles of railway, but shall not exceed a maximum of five miles on any one railway.

7. For marking sleepers zinc nails will be used of the size and shape shewn in the sketch.

8. The zinc nail is to be driven into a countersunk hole, and on the head of the nail is to be punched the necessary marks for registration. After the marks have been punched, the countersunk hole is to be filled in with putty, which may remain until the sleeper is removed from the line.

9. The character of the wood in the sleeper will be indicated by a letter on the head of the nail, as below :—

A—Australian Timber,
B—Babúl,
C—Chíl,
D—Deodar,
E—Creosoted pine from England,
T—Teak,

and such other letters as may, from time to time, be agreed upon, to denote timber not included above.

10. Figures on the head of the nail will denote the year in which the sleeper is laid in the road.

11. Thus the mark $\frac{\mathrm{D}}{80}$ denotes that the sleeper is of deodar, and has been laid in the road in the year 1880.

12. The nail should be driven in on the top of the sleeper, about four inches from one end.

13. There will be no separate store mark on any sleeper registered.

14. The line denoting the half of the year will be discontinued.

15. These rules will cancel Government of India Circular No. 292-315 S. R., dated 27th February 1873.

16. A report on all sleepers, taken out of the selected miles, must be sent to Government at the end of every year.

G. L. MOLESWORTH.

31st January 1880.

Frosts and Forests.

By E. E. Fernandez.

The orders of the Government of India, on the Progress Report of Forest Administration in the Central Provinces for 1878-79, while commenting on some observations made *in the Report concerning the effects of* the severe frosts of the winter of 1878-79 on forest trees, say:—

"*The damage done to young trees by frost seems to be a real difficulty in certain localities in the Central Provinces, and it would be of advantage if some of the young Forest Officers could study the subject, and could compile all available observations regarding it, so as to determine the greater or less susceptibility of different species of tree in this respect.*"

The widespread injurious effects of frost to be witnessed every year in our forests by the most casual observer, struck me from the very first as being one of the most important points to be inquired into before making any serious attempt to restock the large areas of sparse scrub, of which we have become the custodians. Much as I desired it, yet I have

never had either the opportunity or the leisure to carry out that long and sustained series of careful and complete observations, without which all deductions must run the risk of being drawn from insufficient data. But for my own benefit, I have jotted down, whenever the chance occurred, a few notes *en passant,* and since the winter of 1877-78 I have, whenever I could, registered the minimum night and morning temperatures of each day during the cold season. I have thus been able to draw certain general conclusions regarding the effects of night frost on our forest trees. Many of these generalisations will, no doubt, have to be considerably modified, and some even entirely abandoned with more extended and exact observations. But as somebody must make a beginning, I have ventured to state here briefly the results I have been able to arrive at, trusting that others, with more leisure for independent work, or more advantageously placed than myself to observe special phenomena, will freely criticise and record their own experiences in our Forest Journal. In this manner we shall, in time, come into possession of a complete body of facts respecting a subject, the capital importance of which, in sylviculture, is beyond question. If we will only discover sufficient earnestness of purpose in the matter, Government will, no doubt, give every encouragement by supplying the necessary instruments, and affording special facilities for research to a select few, whose tastes and attainments lie in the direction of Forest Meteorology. That this encouragement will not be wanting, when the occasion arises, may be inferred from the orders of the Government of India, quoted at the head of this paper.

I will begin by describing, briefly, what we know concerning the general action of frost on the vegetable kingdom. Without possessing so much preliminary knowledge, it is obviously impossible to study with any fruit the special susceptibilities of our various forest species to frost. Writing out in camp, and under the continual pressure of official duties, I shall no doubt unavoidably omit to notice many points which have been recently, and are being daily, cleared up by the researches of learned German and French vegetable physiologists. Nearly all my illustrations will be taken from facts that have come under my own personal observation.

All parts of plants are bad conductors of heat, more especially so the wood and the corky layer of the bark. The relative conductive powers of wood, glass and copper are as 1 : 5½ : 12,500, while the conducting power of cork is much lower than that of wood. Hence the temperature of the bark and wood of massive stems rises and falls very slowly. The result of this is, that while the temperature of the air is rising, such stems are colder than the surrounding air, and reach their maximum temperature after that of the day has

been attained, the former maximum being of course lower than the latter. On the other hand, as the surrounding air cools much more rapidly than the stems, these are warmer at night than the air, and naturally attain their minimum temperature after the temperature of the air has fallen to its lowest point, and has begun to rise again. They, therefore, never reach so low a temperature as the surrounding air. Thus is explained the almost complete immunity of dormant buds to the effects of frost—thanks to the protective covering of the outer bark, when once the rhytidom has been formed. Hence also the fact that frost seldom kills a well established seedling outright, the part suffering being only the herbaceous portion, the pith of which is still unprotected by a sufficiently thick woody sheath.

But the most energetic cause of fall of temperature in plants, as well as the most rapid in its effects, is, without question, radiation. Hence the roots and the buds at the collum suffer much less than the portions of the plant well above the ground, and, therefore, more freely exposed. Other things being equal, it is obvious that rapidity of radiation is directly proportional to the extent of radiating surface. It hence follows as a corollary, that (*cæteris paribus* understood) the greater the proportion of radiating surface to mass is, the greater will be the susceptibility of the plant in question to frost. We can now understand the reason of the higher sensitiveness to frost of species with large leaves, or with buds, leaves, and internodes possessing a hairy, warty or rough surface, as, for instance, *Sterculia urens*, Teak, *Terminalia belerica*, *T. tomentosa*, *Buchanania latifolia*, *Bombax malabaricum*, *Gmelina arborea*, &c. Thus also may be explained the predominance and more or less complete exclusiveness of the needle-leaved trees (*Coniferæ*) in high latitudes and at lofty elevations.

The energy with which those parts of plants which have an extended surface radiate, is shown by comparing the respective temperatures marked during a clear night by a freely exposed thermometer, resting directly on turf, and by another placed in the air a certain height above the former. The first may register frost, while the second still stands some degrees above freezing point. A further illustration of this fact is afforded by nature herself in the greater abundance of dew and hoar frost deposited on plant parts possessing an extended surface.

If water, containing other substances in suspension, be subjected to the process of freezing, it will be found that, as freezing goes on, the mixture separates, on the one hand, into pure water which congeals and forms ice, and on the other, into a concentrated solution of the suspended substances, the freezing point of which solution is below that of water.

Moreover, as the learned Ruedorff has demonstrated, the act of concentration itself of these substances induces many chemical changes, new compounds being actually formed.

The water contained at any time in a plant is there present in two different ways. One portion of it exists therein as a free liquid, holding certain substances in solution: this liquid is the CELL-SAP of modern botanists. The other portion of the water surrounds and clings fast, by the force of adhesion, to the molecules of the cell-wall, and the substances in the protoplasm, and its quantity remains more or less constant. Physicists apply the term HYDROSTATIC to water in this state. The most perfectly seasoned (air-dried) wood contains hydrostatic water, which can only be expelled by continual exposure to a temperature not lower than that of steam. Now under the action of frost, the hydrostatic water remains unaffected, whereas the water of the cell-sap separates from the protoplasm, and the substances held in solution in it, and oozing out through the cell-wall becomes frozen *outside* the cells (never *inside*). During the process of freezing, the ice crystals grow on by additions to their base, as the water gradually issues from the cell to the outside of the cell-wall. If the frost lasts long enough, the outer surface of the cell-walls becomes encrusted with a constantly thickening coat of ice crystals. As the water within the cell is thus constantly diminishing, the walls of the cells collapse inwards, and the turgescence of the tissues is thus destroyed.* These last become broken, and in the case of large watery leaf stalks, like those of the artichoke, the epidermis becomes completely disunited from the internal tissues, and covers them merely as a loose sac or sheath. Sachs obtained 99 grammes of pure ice, from 396 grammes of an artichoke stalk, or 25 per cent of the total weight of the original stalk. After the frost of 25th November 1879, at Kirgaon, I examined several frost-bitten teak seedlings, some of them five feet high, and found that the connection between the bark and the enclosed stalk had been destroyed in many places. According to Caspary the crystals sometimes grow outwards like combs, the teeth of which gradually tear through the epidermis and protrude out.

When thaw sets in, the ice melts. If the thaw is gradual, the liquefied ice may be reabsorbed by the cell and the cell-contents, provided the frost has not been severe enough to have already injured the tissues beyond all chance of recovery. In that case all the melted ice may be reabsorbed, and the disrupted tissues may reunite, and resume their wonted functions. Indeed it is seldom that death is the direct result

* This collapse is seen in a very striking manner in the frost-bitten tender shoots of the orange plant.

of freezing. For the most part it is caused by rapid thaw, for then the quantity of water outside the walls of the cells becomes all at once too large to be absorbed, and fills up the spaces between the disrupted tissues, usually with a fatal result, causing decomposition of the cell-contents, and the destruction of the molecular structure of the protoplasm and cell-wall.

Watch frozen leaves before thaw begins. As a rule, even when the frost is very severe, they all present the same appearance. Those that are ultimately to die are undistinguishable from those that recover afterwards. But as thaw gradually sets in, little by little the turgescence of the former collapses, discolouration commences, and the leaves gradually dry up, or shrivel up and die.

In the teak seedlings at Kirgaon, referred to higher up as having had the bark disunited from the internal tissues, I found some water in the intervening spaces, after the portion of stem containing them was quite dead, proving that this, so to say, extravasated water could not be reabsorbed. And one of these seedlings, five feet high, which I cut on the 31st January 1880, showed that the pith, and all the tissues of the upper six inches of the stem, were quite rotten from excess of moisture. As I continued making sections lower down the stem, I found the cambium of the bark and wood quite black and rotten all round down to within one inch of the crown of the root, where the woody sheath had not attained a greater thickness than one-sixth of an inch; the woody tissue and pith also were black and rotten. Lower down the stem, where the ring of wood was more than one-sixth inch, but less than a quarter inch thick, both the pith and wood were discoloured and decomposed on two opposite sides, vertically, below the two intervening spaces between the points of attachment of the immediately upper pair of leaves. The other two sides of the rectangular stem were apparently unharmed, owing, no doubt, to the leaves just above them being able to draw up at once, thanks to their suction power, any excess of moisture collected vertically under them. Thus it was clear that whatever the other causes of death were, the immediate cause was excess of moisture which could not be reabsorbed, and which ultimately brought about the decomposition of the tissues affected.

Chemical changes produce a dusky colour in the extravasated sap just as in ordinary expressed sap, and in the case of leaves and herbaceous stems, rapid evaporation soon causes a complete drying up of the dead tissue. The *Butea frondosa* leaf becomes quite brittle within two hours after the setting in of thaw.

The substances left behind in the cell, after the water has frozen outside on the cell-wall, may undergo decomposition, and enter into new combinations. The chlorophyll grains may

become disorganised, the whole protoplasm becoming cloudy and of a brownish or yellowish colour, as in the leaves of the Orange, *Anogeissus latifolia*, *Butea frondosa*, *Pterocarpus marsupium*, *Elæodendron paniculatum* and a host of other trees, or it may become a dusky green as in the *Terminalia bellerica* or assume a blotchy, pale leprous green, as in the partially frost-bitten leaves of the Bér. In other cases the chlorophyll may remain unchanged, while coloured masses, either red or pale yellow, form and occupy the upper part of the cells of the superior surface of the leaves, as in the *Sedum* and *Mahonia*. The red colouring matter here is soluble in water, and gives, on spectrum analysis, the same bands as the red colouring matter of flowers. The change is due to the colouring of the part by radiation. Light does not cause any alteration, and the green colour is restored when the temperature rises. The restoration is a slow process, while the change in colour may be effected in a single frosty night. I would recommend this point to the attention of our Himalayan foresters.

We are now at liberty to lay down the following general proposition, *viz.*, that the greater the quantity of water in the cell-sap is, *cœteris paribus*, the larger will be the quantity of ice formed, the more marked the collapse of the cell-wall, the severer the disruption of the tissues, and the more dangerous the effects of a rapid thaw. We thus see why the sap-gorged tender teak shoot falls an easy victim to frost; also why the *Boswellia thurifera* and *Odina Wodier* are more easily affected by frost than the Anjan and the Bér; and why the *Phyllanthus Emblica* is at once frost-bitten, while the Khair escapes, although, so far as leafy expansion is concerned, the two stand more or less on an equality. We can now understand why air-dried seeds undergo almost any degree of cold without losing their germinative power, and why winter buds of woody plants, that lose their leaves in autumn, withstand all alternations of frost and thaw. These buds are as rich in assimilated solid substances as they are poor in water. Again the reason is now obvious why, in countries where the winter or season of dormant vegetation is immediately succeeded by a well-marked spring or season of reawakening vegetable life, late frosts are always attended with fatal results (all the new shoots are at this time saturated with water); whereas, in countries like most parts of India, where the season for the cessation of growth of the principal forest trees is not the cold season, but quite a different one, *viz.*, the hot weather, which intervenes between the former and the revival of vegetation, it is, of course, evident that the later a frost occurs, the less it is to be feared. On the other hand, it is clear that early frosts are dangerous everywhere, for nowhere, at the time when they occur, is vegetable growth in a quiescent state. To use the vulgar, rather inaccurate, but

forcible phrase, "the sap is still up." The tissues, especially those of the herbaceous portions (stalks, leaves and buds), are more or less gorged with sap, and as growth or rather the metamorphosis of assimilated matter is still going on, the sap is thin and watery. We thus see why in India, and in other countries in which vegetable growth is continued although with constantly decreasing activity throughout the whole winter, to cease only at the commencement of the immediately ensuing hot weather, frosts, even the mildest, are always to be dreaded.* Hence it is not quite correct to say, as even many scientific foresters are wont to express themselves, that the year's shoots succumb to early frosts, because they are not yet "properly or sufficiently liquefied." At best this way of putting the fact conveys only a partial truth, and is extremely misleading. It is quite true that proper lignification by interposing a sheath of a badly conducting substance like wood, protects the pith against the cold of the outside air; but what effect can it have on the buds, the death of which means the death of the shoot? Moreover, the woody sheath must be fairly thick, if it is to afford the necessary protection to the pith. At the Kirgaon Nursery in Nimar, the pith of teak seedlings was killed by frost although surrounded by wood one-sixth inch thick. The main point to remember is that, in order that the shoot in question may be placed in the best conditions to withstand frost, the growing season must have passed, or be sufficiently advanced, for the sap to contain the greatest proportion possible of solid matter in the shape of the reserve food stored up for use at the beginning of the next growing season.†

Plants possessing tough leathery leaves, like the *Celastrus senegalensis*, *Hardwickia binata*, Pipal, Bér, the Mistletoes, &c., generally resist frost well, and the mosses, fungi, and the so-called lichens, which are nearly always dry and leathery, seem never to be affected at all. The texture of their tissues, as well as the smoothness of their parts is, no doubt, one of the chief causes of their low radiating power. But the present state of our knowledge on this point is not sufficiently advanced to warrant any general rule being deduced. We can, until further study brings new facts to light, only say that the nature itself of the plants conduces in a manner still undefined to the faculty it possesses of resisting frost. With respect to the mosses and fungi, and what we shall still call lichens, we know that their

* This fact cannot be too much insisted upon, for people, carried away by the present acclimatisation mania, fondly imagine that because trees from the temperate zone stand the most rigorous winters in their own native clime, it therefore follows that they will thrive when transplanted to the highlands of India, if only the conditions of soil, temperature, and rainfall be the same. Let them remember that our alternation of seasons is not the same, and that rapid, almost instantaneous, thaw is the invariable rule, not the exception.

† This remark does not apply to leaves, which seem to be more sensitive the nearer they are to their shedding time, as will be seen lower down. The question here is the vitality of the shoot itself.

vitality is not only proof to extremely low degrees of cold, but also to complete drying up, whether this is caused naturally or artificially.

In the same way different varieties of the same species are distinguished by their different degrees of sensitiveness to frost. I have myself no doubt *that careful and intelligent study will* show that these various relative degrees are simply the combined result of modifications effected in the size of the leaves and in the nature of their surface, in the rapidity and vigour of their growth, in the period of the year for the fall and renewal of their foliage, &c. So far as frost is concerned, the acclimatisation of a plant, introduced into a country the meteorological conditions of which differ from those of its habitat, is possible only on the supposition that such favourable modifications can be gradually produced.

A little reflection will show that the depth, nature, and composition of the soil and sub-soil, in which a plant has its roots, influence, to a considerable extent, its sensitiveness to frost. When the soil is favourable, and growth rapid, early frosts will find the shoots charged with sap, and vegetation still more or less active, these circumstances being aggravated in countries possessing seasons like ours in Central India, where all forests possess the characteristic of early frosts. On the other hand if the soil is poor and shallow, and the sub-soil is hard, and presents no facilities for the penetration of the roots into it, like the masses of sheet rock, which form so peculiar a feature of a great part of the trap country, the roots remain superficial and exposed to extreme alternations of temperature, and the shoots of the year are thin and weakly, and experience the effects of frost in their greatest intensity. Thus in the cold weather of last year, young *Hardwickias* growing on sheet-trap in the Khandwa reserve, and in the moist, rich, deep-soil, sandstone valleys of Punasa, were all more or less frost-bitten, while those standing in medium soil or on freely fissured rock, were scarcely touched at all. Again in the cold weather of 1877-78, the Bér bushes in the deep, moist, rich soil below the village of Desli in Kalibhit suffered very severely, more so even than Dhaora (*Anogeissus latifolia*) in medium soils, while bushes of the same height in the vicinity, where the soil was of an average type, escaped without any injury at all.

Before proceeding to the next point, it may be noticed here that, other things being equal, the injurious effects of frosts are greater, the further they occur from the solstice, for the sun is then more powerful, and then, therefore, all the more rapid.

The dew-point or relative humidity of the air affects the greater or less sensibility of a plant to frost. The greater the relative humidity, the more intense the hoar frost, and hence the severer its effects on vegetation. This is why the ravages of frost, along river banks, in swampy ground, and in low-lying

situations, generally are greater than in other localities, and why small bushes and the lower branches of trees are frost-bitten, when tall poles and the higher branches are either not affected at all, or are affected relatively only to a slight extent. When fogs prevail, the destructive effects of frost are clearly defined by a line coinciding with the height of the fogs. On elevated ground, solitary teak trees, 20 feet high, may resist as low a temperature as 21° Fah. without showing a single frost-bitten leaf, whereas in low, moist situations all the leaves, and many of the young shoots and buds, would be killed by a temperature of 25° Fah. In India one of the causes of the greater severity of early frosts is the greater saturation of the air owing to the proximity of the monsoon just past.

Captain Losack has recorded that fire conservancy tends to heighten the susceptibility of forest trees to frost. It would be interesting to know whether the experience of other forest officers coincides with that of Captain Losack. Any opinion on the subject can be valuable only on the indispensable condition of long and continued acquaintance with the forests concerned, which must have been protected from fire for a sufficient number of years to allow of the comparative severity of successive winters being fully considered in deciding the question at issue. For instance the past two winters in the Central Provinces have been exceptionally severe. I do not believe as low degrees of cold have ever been registered before, since meteorological observations have been regularly taken and recorded here. It would, therefore, be unfair to charge to fire conservancy the greater destructiveness of the frosts of 1878-79 and 1879-80. Of course there is no *á priori* objection against Captain Losack's conclusion regarding this subject. Indeed it is quite possible that the increased humidity, both of the soil and atmosphere, due to successful fire conservancy, does, by raising the dew-point and producing more generous growth, aggravate the injurious effects of frost. But, on the other hand, enhanced vegetative vigour signifies more cover, and, therefore, greater impediment to radiation, the most energetic as well as the most rapid cause of fall of temperature. I myself can offer no opinion on the subject, as my longest acquaintance with a fire-conserved forest extends over only five years, and I do not possess sufficient data to draw any inference of greater value than mere guess-work. This much I can say with certainty, that during neither of the two past winters, unexceptionally severe though they were, did I observe that the vegetation in the fire-conserved forests suffered more than in the adjoining private or Government non-conserved forests.

My observations seem to me to tend towards establishing the general proposition that, with deciduous trees, early leaf-shedding is directly connected with the sensitiveness of the leaves themselves to early frosts. The *Boswellia thurifera*, *Odina Wodier*,

Bombax malabaricum, and *Sterculia urens* are among the very first to shed their leaves, and they show most conspicuously of all the injurious effects of frost. Of course there are other causes, as shown above, which operate to render them extremely sensitive to low temperatures. For instance, the first three species are rich in sap, while the *Bombax* has also, with the *Sterculia*, large leaves. But that early leaf-shedding has some connection with the marked manner in which these trees bear evidence of the effects of frost, will, I think, be admitted from what follows. On the 19th November 1879, the thermometer fell to 19°Fah.; nevertheless numerous *Butea frondosa* trees, from 25 feet to 30 feet high, showed few signs of frost bite. On the 6th and 7th December following, the minimum temperatures were respectively 21° and 23°, *i.e.*, from two to four degrees higher than on the 19th November, and yet the *Butea* suffered on those two nights, or rather mornings, more than on the latter date. Again, on the 25th, 26th, 27th and 28th January 1880, the lowest temperatures were respectively 21°, 22°, 25° and 28½°Fah., *i.e.*, the temperature on those days was from 2° to 7½° warmer than on the 19th November, and for the first two days about the same as on the 6th and 7th December, and higher by several degrees on the two succeeding dates, and yet the effects of these last-mentioned frosts on the *Butea* were much more marked than those of the preceding severer ones. Whether this greater susceptibility of the leaves is due to their diminished vitality, and, therefore, lessened recuperative power as the time for shedding approaches, although a likely explanation, can only be, for the present, a matter of conjecture. The fact is there clear and indisputable. Other species, as far as I have observed, have behaved similarly, though not in so marked a manner as the *Butea*. The *Zizyphus* and *Celastrus senegalensis* may be quoted as instances out of a number.

(*To be continued.*)

A Submarine Forest at Bombay.

In 1878, when excavations were made on the east side of the Bombay Island for the Prince's Dock, the Engineers found stumps of trees at a level of 12 feet and more, below extreme low-tide mark, proving a considerable subsidence of the land on that side of the Bombay Island. An account of this remarkable discovery was published in their Records for 1878, by the Geological Survey, with a note by Mr. W. T. Blanford, which we reproduce below. But it will doubtless interest the readers of the "Indian Forester" to have some details relating to a subject which has a special interest for foresters. These details have been extracted chiefly from a late report by Mr. Ormiston, the Resident Engineer of the Bombay Port Trust.

The bottom of the dock is 45 feet below the B. M. Stone at the Bómbay Town Hall, the surface being about 21 feet below that mark, and nearly 2 feet below mean water level.

The excavation has opened out five distinct strata, the lowest of which is a rock with an extremely uneven surface. The rock (probably trap, though this is not stated in the report) was in places covered by moorum, and this by black loam. The black loam was overlaid by a stratum of stiff blue clay from 6 to 20 feet thick. The surface of this blue clay was nearly level, and the remains of branches, twigs, and reeds are distinctly traceable in it. The uppermost stratum was soft black clay or silt. The trees were growing, on an uneven surface on the rock, and some on the moorum and black loam overlying the rock. The soil was generally very scanty, often not more than four to six inches thick, and the roots were spread out almost at right angles to the trunk. In some of the fissures of the rock there was black muddy loam, possibly the remains of decayed roots. Altogether 382 trees were found. They varied considerably in length and thickness, but appeared to be of contemporaneous growth—223 were standing upright, and 159 had fallen. The largest tree was 4 feet 8 inches (according to the latest report 36 inches only) in girth and 46 feet in length; this was found on its side. Several others of equal girth were standing upright, but the upright trees were all broken off near the surface of the blue clay. The trees were standing at different levels, the highest being at low water level of extreme spring tides, while the lowest was 16 feet below low water level. Some of the forest in the Sundarbans is not much higher than the low water level of spring tides. But this forest evidently had a character different from the Mangrove and Sundri Forest on the deep mud of the Sundarbans. These trees had grown on rock, or on the scanty soil overlying that rock, and the forest probably stood above high water level. The difference at Bombay between low and high water, at extreme spring tides, is 16·60 feet, so that the subsidence, as indicated by the position of the trees, must have been more than 32 feet. The stumps which protruded through the blue clay into the silt were completely riddled to a short distance into the blue clay by the perforations of the *Teredo navalis* or another similarly destructive animal. Lower down, the holes became fewer, and many of the trees, when cut through into blocks, showed a single hole winding towards the roots, and getting larger as it approached the foot of the tree.

Of the trees found lying down, some must have drifted as they were without branches or roots. The large fallen down tree, mentioned above, had left a complete cast of its branches in the blue clay, though the woody matter was gone.

Apparently all the trees were of the same kind, except two, which it is said looked like teak trees. The wood of the others is described as fine grained, and dark like rosewood.*

No certain remains of any kind were found which might have indicated human habitation; nor were any shells or other organic objects discovered in the blue clay or the ground underneath it, except one oyster shell which was imbedded in some gravel in a crevice of the underlying rock.

But it is mentioned that traces of twigs and seeds were noticed, the latter having left impressions of their shapes in the blue clay, a fine film at the outside skin in some cases adhering to the clay. None of the casts were more than half an inch wide, but they were found close together, and in a vertical position.

Below the places where these casts of seeds were traced, it is mentioned, that the loam stratum was perforated with holes like rat holes, and that these were filled with very fine clay nearly as fluid as cream. Some of the holes commenced from the surface of the loam, penetrating it for the length of a foot; others ran in a horizontal direction.

The area excavated is about 30 acres; thus there were, on an average, seven trees per acre standing. But in addition to these, some of the fallen trees had probably grown on the spot. The trees were not, however, equally distributed, but were found grouped in large clusters on a portion only of the area.

Leaving to the geologist the further discussion of this most remarkable discovery, it will be well here to offer a few remarks which may be of interest to our readers. So much seems clear, that, after the land on which the trees grew had subsided below the sea, a deposit of clay, gradually and slowly, settled down upon the trees, and that at a later period a second deposit coming from another source, and consisting of soft silt followed.

The trees were probably killed by continued immersion in water. Soon after they had been killed, and before the deposit of stiff clay had settled around them, they were broken, and blown down by winds and waves. From what is stated in the reports which have furnished the data for these notes, it would seem that the wood is in no way petrified, but has preserved its character in a remarkable manner. It would be well to examine the structure of the wood found, and to compare it with that of Indian woods of the present day,

* We have received specimens of two kinds of wood: the first is rotten and has lost nearly all trace of structure, but the characteristic odour as well as the colour and texture proclaim it to be unmistakeably 'Teak'; the second is sound and good and is a hard dark red wood which in structure corresponds with 'Khair' (*Acacia catechu*). The darker colour is probably the result of its long sojourn in the mud.—ED.

in order to identify them, and determine whether they belong to families which are extinct, or are still found in India.

2nd September 1880. D. B.

NOTE BY MR. BLANFORD.—This discovery of trees, in the spot on which they grew, below low-water mark in Bombay Island, is chiefly remarkable, because it shows that, in recent or sub-recent times, depression must have taken place in the immediate neighbourhood or ground which appears to have been raised The Prince's Dock is on the eastern or harbour side of Bombay Island, and the Esplanade surrounding the fort on the western side, not a mile away from the dock, is composed of the rock called littoral concrete by Dr. Buist, a mass of shells, corals and sand, cemented together by carbonate of lime. It is scarcely possible that the materials of which this rock consists can have been accumulated at their present elevation above the sea; in all probability they formed, when first deposited, a sand bank or beach not raised above high-water mark, and as it is difficult to understand how elevation and depression can have occurred simultaneously on different sides of so small an area as Bombay Island, it is probable that the whole area has undergone elevation and depression alternately. If the elevation be the older movement, then the Esplanade must once have been several feet higher than it now is; if the depression is older, the trees at Prince's Dock have been at a greater depth beneath the sea than they now are. The former is perhaps more probable.

That such alternate movements of elevation and depression have taken place in Bombay Island, was shewn by Dr. Buist many years ago, though to a smaller extent than now appears probable. At the same time, before the depth to which depression has extended in this case, can be estimated, it is necessary to ascertain what kinds of trees are represented. If they be such as grow on land, the depression must have been greater than if they belong to such forms as *Avicennia* or *Bruguiera*, which grow some feet below high-water mark. The circumstance that the trees are bored by *Teredo* is in favour on their having grown in salt marsh, where these mollusca are peculiarly abundant.

A visit to Mount Faron near Toulon, France.

WHILST on a tour in the south of France, I did not of course omit the opportunity of visiting the famous Mount Faron, about which we have heard a good deal from time to time. Full details of this interesting reboisement work are to be found in the Forest Conference Report of 1874, but a few particulars of my own observations may interest some of the readers of the "INDIAN FORESTER." Not having been fortunate enough to find any one thoroughly well acquainted with the progress of the works during my short visit, allowance must be made for the incomplete information obtained. This mountain forms what may be called the centre part of a range of hills of magnesian *limestone, which stretches along the north of* Toulon, and presents a very desolate and forbidding appearance as far as show of vegetation goes, so that on the whole, it struck me as being of as dry and barren a nature as any of the arid hills of Rajputana or the Punjab.

Although a good deal has been said about the dangers of denuding a mountain of this kind, still, on the whole, the risks are not half so great as in the case of the black marl hills of the *Hautes* and *Basses Alpes*, for the hill being composed of hard limestone, the formation of mud and boulder torrents, with attendant landslips, &c., cannot occur.

Although considerable damage to cultivation has resulted from the felling of the forests on the slopes of this mountain, it is rather too much to say, I think, that the harbour roads were

obstructed by the "debris," &c., or that the hill consists of a mass of rolling stones as the descriptions would lead one to believe.

The area submitted to reboisement treatment is about 365 hectares, the whole of which belongs to the Municipality of Toulon, but this mountain forming one of the principal points of the defences of Toulon, all forest operations are subject to certain military rules and regulations.

The average rainfall is about 28½ inches, which is much above the average of that of most of the drier parts of India where works of a similar nature have been undertaken; besides, the proximity of the sea must necessarily render the atmosphere extremely moist. There is also a considerable fall of dew, and although the climate is decidedly hot for Europe, and droughts frequent, yet taking everything into consideration, the heat and dryness are nothing like that of Rajputana or Northern India.

Judging from some single trees and patches of the ancient forest still apparent, the natural vegetation seems to have consisted principally of Scotch fir and Maritime pine; and considerable areas of forest composed of these species still exist in other parts of the range.

The undergrowth consists principally of broom, juniper, brambles, and several kinds of oaks; but owing to the fact that seeds of all kinds of plants were sown on this mountain, when operations were first commenced, many strange shrubs and bushes are now to be seen, and form quite a study for the botanist. This tract has now been subject to the strictest conservancy rules for upwards of 27 years; and, as the portion belonging to the town of Toulon at least had been reduced to a complete state of barrenness, and, therefore, hardly capable of affording any grazing whatever, there could not have been much trouble in inducing the neighbouring inhabitants to give up their grazing rights. Besides this, they are said to have for many years abandoned the custom of keeping large flocks, and confined themselves to the cultivation of vines, olives and figs, which was found to be much more profitable.

The difficulties encountered in some parts of India, when grazing is to be excluded from certain reserved tracts, in the neighbourhood of which the principal source of welfare of the inhabitants consists in keeping large flocks of sheep and goats, is well known; and no comparison is admissible between the success of the exclusion of cattle from Mount Faron, and similar attempts in India, especially when the inhabitants in the neighbourhood are, in some cases, only half civilized, and altogether incapable of understanding anything but the actual loss of their grazing, even though none in reality exists.

I must confess, however, that I was rather disappointed with the show of natural vegetation, represented by 27 years

conservation, and could point out several tracts in various parts of India, which, when taken in hand, were probably equally barren, and where, notwithstanding the great difficulties of keeping out cattle, now exhibit a much better natural growth, even after five or six years conservation only. The principal method employed for effecting the reboisement of this tract has been by means of sowings in pits dug about 0·80 to 1·00 metres in depth, all the available soil being collected at the bottom.

This, on an average, left an empty space of about 0·50 centimetres, which had the advantage of giving the young plants a certain amount of shelter during their early growth.

Owing to the very hard rocky nature of the soil, which necessitated the digging or rather quarrying out of the pits at those places when there was a likelihood of encountering fissures in the rock, the pits are very irregularly distributed over the surface, but, as a rule, they are placed from three to five metres apart.

Most of the pits are filled with strong plants of Aleppo pine, Maritime pine, Holm oak (*Q. ilex*); Acacia (*Robinia*), &c., of all ages, as the sowings often failed, and had to be executed over and over again. About five per cent. of the pits are empty, the rock having proved too compact to allow the roots to penetrate. Planting with strong plants would undoubtedly have succeeded better, but when sowing was found to answer, and being at the same time less expensive, it was naturally finally adopted.

Some of the trees of the older plantations are now from 15 to 20 feet high, and seem to be in a most flourishing state, with the ground underneath well covered with humus. Nearly the whole area has now been completed, with the exception of the parts situated in the immediate neighbourhood of the fortifications, and on the side next Toulon where the ground is for the most part precipitous.

The cost of these works is said to have amounted to about 100 francs per acre, which is much less than the expenditure on other reboisement operations in the Hautes and Basses Alpes, and where the cost has amounted, in some cases, to as much as 350 francs per acre; but it must be recollected that in the case of Mount Faron no masonry weirs or other works of an expensive nature have been constructed.

The planting of resinous trees seems to have been intended originally as a transitory species, to be replaced eventually by deciduous trees, suitable for coppicing, when it became necessary to clear portions of the forest for military operations; but however good the theory, the idea has not been found altogether practicable, as it appears that pines only will grow on the hard limestone rock.

All attempts at planting larch, cedar, eucalyptus, &c., have naturally failed. Although the reboisement of Mount Faron has been an undoubted success, and has been executed

apparently at a very moderate cost, still it must be recollected that, on the whole, the conditions of rainfall, climate, experience, skilled labour, supervision, &c., are much more favourable than in the case of any similar works undertaken in India.

It may be argued that in India there are certain species of trees capable of *withstanding long droughts and excessive* heat for a much longer period than any European species, which must of course be admitted; but, on the whole, I think it must be allowed that the conditions are decidedly very much in favour of the success of the Mount Faron operations, even though the conditions are perhaps as unfavourable as can be found in Europe.

E. McA. Moir.

Precautions to be taken in felling trees singly in dense forests.

When a tree is to be felled in a well-stocked forest, it is most important to preserve the neighbouring trees and young tender seedlings from injury.

I have invariably noticed that by the careless felling of trees, especially by private purchasers, many young seedlings and trees of immature growth are broken down by the fall of a big tree, and die in consequence.

It is necessary, therefore, when a tree is to be felled, first for us to determine *in which direction there are fewest seedlings* and trees, for in that direction the tree ought to be felled; and, accordingly, I would suggest that the departmental mark be placed on the tree on that side.

It would be necessary to impress upon the wood-cutter that, whichever side of the tree bears the departmental mark, in that direction the tree must be felled.

If the tree has many large branches, these as well as all creepers, should be cut down before felling the tree; and instructions should be given at what height the tree is to be cut. If it is settled that the tree *is to be cut at two feet from the* ground, the wood-cutter must be carefully instructed first to cut the tree with the axe very deep on that side of the tree to which it is intended to fell, and about nine inches lower than the cut to be made on the opposite side of the tree. When the tree has been cut on both sides, and about three parts through, then the remaining portion should be cut by the saw on the opposite side or back of the tree, which will then come down straight in the direction intended.

The above method in felling trees has been tried, and the result found almost certain. And by insisting on *this method* being carefully used, the wood-cutter may rescue the lives of many valuable seedlings.

S. C. Chuckerbutty.

Forests and Arboricultural Work in Queensland.

We have received from Mr. L. A. Bernays, the Vice President of the Queensland Acclimatization Society, a copy of the Society's Report for 1879, together with a paper by himself on the subject of Economic Tropical Horticulture in Northern Queensland.

From these papers it appears that the Society, though poor, and supported by the meagre Government grant of £500, is doing a great deal of good work for the colony, not only in acclimatizing useful exotic animals and plants, but also in furthering the development of indigenous products, and even the preservation and conservation of the forests. On the subject of forest conservancy we quote as follows :—

"Having been desired by you, verbally, to make any observations in my power, which might assist in dealing, hereafter, with the question of Forest Conservancy, I lost no opportunity of comparing my own views upon the subject with those of many intelligent persons engaged in various ways in timber-getting. There can be no question that the subject is one of extreme importance to the future of the colony ; and the fact that we have still enormous tracts of timbered country, affords facilities for dealing successfully with the question, inasmuch as, if now systematically and intelligently handled, the costly and difficult phase of replanting need never arise.

"Further experience has induced me materially to modify the views expressed to the Government in 1871, when I was honored by an invitation to make suggestions for a Forest Conservancy system. I am now quite satisfied that no really practical good can be effected until the Government are prepared to appoint departmental officers of various grades, whose duties shall be *solely* confined to regulating and guarding the felling of the natural timbers, and the creation and preservation of timber reserves. The example of India abundantly proves that this may not only be accomplished without being a charge upon the State, but that such a department, properly worked, may be made a source of revenue. Gazette notifications upon the subject of felling timber are of no practical effect unless the orders of Government are enforced ; while to do this effectually, the officers charged with the duty should not have their attention distracted by the imposition of other incongruous duties. The Indian Forest Department is so admirably organised, and its success has been so marked, as to indicate it as an excellent type on which to found a department of our own ; and there is little doubt that the Government of India would willingly lend to the Queensland Government, a competent officer to examine our forests, and to prepare a scheme for their management and preservation. The expense of this preliminary step would not be great, nor need it com-

mit the Government as to their course of further procedure, while it is more than probable that a plan would be devised under which a Forest Department could be made, at the least self-supporting, and, in course of time, even a source of revenue."

And from these remarks it is clear that if forest conservancy is attempted in Queensland, it will be on broader principles, and on a more generally correct basis than the work in South Australia, which we reviewed in our last number.

On the subject of the *Cedar Forests* (*Cedrela*) we quote as follows :—

"In the meanwhile, as our rich cedar forests are all too rapidly disappearing, a preliminary step might, with advantage, be taken by the issue of a memorandum to the various persons engaged in the cedar trade, inviting suggestions from them for regulations, which, while not needlessly repressing the industry, would prevent much of the heedless felling of this valuable timber, which, despite existing regulations, is now undoubtedly going on. From conversation with many persons, both masters and men, engaged in the trade, I find every disposition to submit to the enforcement of reasonable regulations for this object."

But we hope the Queensland Government will not waste more time in inviting opinions, but set to work in earnest in demarcation.

Mr. Bernays' report gives an interesting list of exotic trees successfully introduced into the colony, and mentions that many Indian trees, especially teak, thrive admirably. We wish the Society every success, and hope that some good practical results will follow their recommendation of Forest Conservancy.

IV. NOTES, QUERIES AND EXTRACTS.

SOUTH AFRICAN TIMBER.—The following is extracted from "The Colonies and India." The useful kinds of timber indigenous to South Africa number some hundred varieties, only a few of which, however, have hitherto been used for manufacturing purposes, and those only to a limited extent: and yet, although the forests cover an area of many thousand square miles, there are not wanting indications in certain districts of a falling-off in the supply. The colonial authorities are fortunately taking steps to encourage tree-planting and forest conservation generally, and, at the same time, we are glad to see that they are not losing sight of the equally important question of at once utilizing the natural wealth of the country. Hitherto the colony has imported not only her rails, but the sleepers also, instead of utilizing some of the durable timber awaiting consumption within her borders. The principal South African forests are within a short distance of the shore; and as the denser part of the population is located round the coasts, and the railways are consequently confined to within a comparatively short distance from the seaboard, it would have seemed the natural course for the colonists to have utilized their native supplies of timber in their construction. The people, however, did not actually know the extent of their own possessions in this respect, and custom had probably a good deal to do with the maintenance of the system of "bringing coals to Newcastle," which has gone on so long. Now that the railways have thoroughly tapped the forest country, the utilization of native timber will become more general, and more stringent laws for the preservation of the forests from further drain will be necessary. The cutting of timber and brushwood in the Crown forests is placed under strict surveillance, and licenses are required to be taken out by all persons cutting timber therein. The measures adopted for their preservation, however, are a heavy item in the expenditure of the Government; and the forests, instead of being a source of revenue, are actually a dead loss, costing £2,500 in Cape Colony alone every year, and yielding only £2,000. Many of the preserves, however, will bear largely thinning out; and with proper management, and new openings for the use of their produce, they ought rapidly to become a profitable property.—*Timber Trades Journal.*

THE MANUFACTURE OF RESIN AND TURPENTINE.—From Wilmington, N.C., southward, and nearly all the way to Florida, the pitch pine trees, with their blazed sides, attract the attention of the traveller. The lands for long stretches are almost worthless, and the only industry, beyond small patches for corn or cotton, is the "boxing" of the pitch pine trees for the gum, as it is called, and the manufacture of turpentine and resin. There are several kinds of pine trees, including the white, spruce, yellow, Roumany, and pitch pine. The latter is the only valuable one for boxing, and differs a little from the yellow pine, with which it is sometimes confounded at the north. The owners of these pine lands generally lease the "privilege" for the business, and receive about 125 dols. for a "crop," which consists of 10,000 "boxes." The boxes are cavities cut into the tree near the ground in such a way as to hold about a quart, and from one to four boxes are cut in each tree, the number depending upon its size. One man can attend to and gather the crop of 10,000 boxes during the season, which lasts from March to September. About three quarts of pitch or gum is the average production of each box, but to secure this amount the bark of the tree above the box must be hacked away a little every fortnight. Doing this so often, and for successive seasons, removes the bark as high as can be easily reached, while the quality of the gum constantly decreases, in that it yields less spirit, as the turpentine is called, and then the trees are abandoned. The gum is scraped out of the boxes with a sort of wooden spoon, and at the close of the season, after the pitch on the exposed surface of the tree has become hard, it is removed by scraping, and is only good for resin, producing no spirit. The gum sells for 150 dols. a barrel to the distillers. From 16 barrels of the crude gum, which is about the average capacity of the stills, 80 gallons of turpentine and 10 barrels of resin are made. The resin sells for from 1·40 dols. to 5 dols. per barrel, according to quality, and just about pays for cost of gum and distilling, leaving the spirit, which sells for 40 cents a gallon, as the profit of the business. Immense quantities of resin await shipment at the stations along the line, and the pleasant odour enters the car windows as we are whirled along. After the trees are unfit for further boxing, and are not suitable for lumber, they are sometimes used to manufacture tar, but the business is not very profitable, and is only done by large companies, who can thus use their surplus labour. The trees are cut up into wood, which is piled in a hole in the ground, and covered with earth, and then burned the same as charcoal is burned elsewhere. The heat sweats out the gum, which, uniting with the smoke, runs off through a spout provided for the purpose. A cord of wood will make two barrels of tar, which sells for 1·50 dols. per barrel, and costs 37½ cents to make. The charcoal is then sold for cooking purposes.—*North-Western Lumberman.*

A SCHOOL OF FORESTRY FOR THE UNITED STATES.—A Bill for the establishment and maintenance of a school of forestry at St. Paul, Minn., has been introduced in the Senate by Senator McMillan. It would seem to be time that some attention was paid in this country to the conservation of our forests, and this proposed school seems to be a step in that direction. As a means of supporting the proposed school, the Government is called upon to grant 300 sections of the public lands of the State, to be selected by an agent appointed by the Governor, with the approval of the Secretary of the interior. Not more than two sections are to be taken from any one township, and the selected are not to be mineral lands. The sections are then to be sold, and the proceeds invested in United States or other safe stocks, at not less than 4 per cent. interest. The capital is never to be diminished, and the interest is to be appropriated for the endowment and support of the school, which shall give instruction in the science and practice of forestry, as adapted to the climate and soil of the State. Ten per cent. of the interest may be set apart for the purchase of lands for experimental out-stations for tree culture on prairie lands, and forest culture on lands, when such experiments shall be authorized by the Legislature. No part of the fund or interest to be used in buying, erecting, or reparing the school building, and unless the school is provided with a suitable building, and 40 acres of land for experimental timber culture, within eight years, the grant is to cease. The State must employ, at the head of the school, a person of known qualifications in the science and practice of forestry, and the tuition is to be free. Pupils are to be admitted from any State. An annual report of the progress of the school, and the results of its experiments, is to be filed with the Librarian of Congress and the Commissioner of the general land office.—*Lumberman's Gazette,* quoted in *Timber Trades Journal.*

IN an article in the Transactions of the Royal Botanical Society of Edinburgh, for 1879, on the exact measurement of trees, by Sir R. Christison, the tendency of the deodar to have its top shoot bending over is talked of as an "unhappy failing," and regrets expressed that it will not shoot upwards freely as it ought to do. Sir R. Christison has, we suppose, ere this been told that, so far from an unhappy failing, the bending over of the top of the deodar is as much a characteristic as the strong erect top shoot is of the spruce or scotch fir. If he had referred to Brandis's Forest Flora, he would have seen that soft and drooping terminal shoots were one of the characteristics of the tree.

THE following remarks, on the assistance given by forest officers to the Museum at Lahore, occur in the review of the

Curator's Report for 1879-80, by the Lieutenant-Governor of the Punjab, in the *Punjab Gazette* for July 15th :—

The most notable improvement of the year is the re-arrangement or rather the renewal of the section showing the woods of the country generally and of this province, which has been done by Mr. B. H. Baden-Powell. The woods of the country are now arranged in billets of uniform size, according to the classification by natural orders, and on the other side those of the province so set forth as to show the products of the upper hills, the lower hills, and adjacent country and the plains. Woods in ordinary use, those of rarer kinds, and those used as fuel, are also discriminated. Mr. Baden-Powell has also contributed pictures of the ravages of sand streams consequent on the denudation of the upper hills, the "chos" of the *Hoshiarpur district*, and other sketches. Under his care and with the co-operation of Dr. W. Schlich and other officers of the Forest Department, this section will become a really valuable exposition of this important subject.

THE following notice is copied from the Paper Maker's Monthly Journal of 15th June 1880 :—"The Florida *Mirror* says that palmetto paper manufacturing is a perfect success, and that it is the intention of the Company, which has been experimenting, to establish about twenty mills in Florida, at places where the material will be near at hand, and transportation easy." This encourages the hope that the leafstalks and leaves of the palmetto of the Trans-Indus territory (*Chamaerops Ritchieana*) which covers a vast extent of country, may eventually find a market for the manufacture of paper.

CYPRUS.—From the report of Her Majesty's High Commissioner, Major-General Biddulph, we extract the following observations :—The planting and preservation of trees have engaged the attention and care of this Government. Great pains have been taken to plant the eucalyptus, and considerable expense incurred for the purpose both by fencing it to preserve it from cattle, and owing to the necessity of its being constantly watered for the first two years. A large plantation at Famagusta has been entirely destroyed during the last few days by the excessive cold, which, for intensity and duration, has been unequalled at that place during the last forty years. With a view to encourage the importation of timber, and to save, as much as possible, the remaining forests, the import duties on all timber, whether manufactured or otherwise, and on all fuel of every description, has been entirely removed.—*Timber Trades Journal.*
